AN ELEMENTARY TREATISE ON HOISTING MACHINERY

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PREFACE.

THIS work is an attempt to present in a concise form the leading characteristics of the various types of cranes now made. These are so numerous that a full treatment of all of them would be impossible in a single volume, even of larger size, and the aim has been to keep the book within small limits. Several types have become, or are fast becoming, specialised in the hands of a few firms. The writer has had a long experience in the work of crane construction, and in the course of those years has become familiar with all the types he has here described, with the exception of a few that are patented specialities.

The concise and summary treatment necessary, if the subject were to be dealt with in a handy volume, has made it impossible to deal with any single type of crane at length. The writer has adopted, therefore, what seemed to be the best method under the circumstances—namely, to occupy the greater portion of the work with an account of the elementary portions, the main features that are common to many cranes, leaving the leading types to be described in a condensed fashion. Thus, although few cranes are illus-

trated, their elementary parts are shown as far as space would permit.

Another point is that formulæ have not been introduced. This matter was well considered, and the writer deemed it better to omit them altogether than to attempt even a small selection, which would have lessened the already limited space available for the practical treatment of the subject.

A great deal might be said on both sides of this question of formulæ. The true point of view, it may be suggested, is that it would be difficult to give any selection which would not be open to criticism. One important fact is, that different men arrive at the same results by different ways. Graphic methods are employed in crane shops to a far greater extent than mathematics. There is no time for extended calculations, neither is the risk run. Books of tables, moments of inertia, are used largely. Much work is not calculated at all, but the accumulated data of the firm are simply drawn upon. Then with regard to simple calculations — involving leverage, crushing, tensile strengths, &c.—these are already available in numerous elementary text-books.

Such are the principal reasons why the purely "shop" method of treatment of the present subject has been deliberately adopted in the present volume.

JOSEPH HORNER.

BATH, *August* 1903.

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INTRODUCTION.

Value of Experience—Standardisation in Crane Shops—Variable Character of Stresses and Strains—Nature of the Problems involved.

In no structures built by engineers is the question of due relation of strength to stress of greater importance than in cranes. Yet in few does more empiricism exist, in few is the accumulated experience of success and failure of greater value,—a case which has notable parallels in the history of the development of the locomotive, and of machine tools, neither of which are much indebted to theory.

There are certain crane elements in regard to the strength of which calculations are of much value, because the stresses are readily obtainable by the methods of graphic statics. These are the elements of which the frames are built, and the strains on chains, hooks, and snatch blocks. But the main side frame castings, and the plated frame castings are not readily calculated, and in fact are almost invariably copied or modified from previous designs that have stood successful service. In the drawing offices of crane shops new designs are got out without much direct calculation, because previous practice is drawn upon. The more highly the work of a firm is specialised, the more easily

can modified designs be produced. Thus, there are tables kept in the office giving loads for various sizes of chains, the strength of the different standard hooks used, the strength of rods of various cross sections, and much more of the same character, by which direct, often repeated calculations are rendered unnecessary. Then there are certain trains of gears, and drums which have been previously used, and these can be taken *en bloc*, and put on other cranes that vary in details of design. Jibs are standardised for different radii and power, and these need not be recalculated. So are trucks, posts, ground wheels; and finally there are standard superstructures that can be taken bodily and put on either portable or fixed bases. In the latest stage of all, standard cranes are made in a wide range, and kept in stock for immediate delivery. Thus it happens that youths may spend much time in modern drawing offices and yet never have opportunities of calculating the stresses throughout a crane, or even what is of more importance, of understanding the conditions of actual service, which profoundly modify these calculations.

The reason why calculations are so greatly modified is that though stresses can be obtained for certain elements with absolute precision, and in others with a fair approximation thereto, the uncertain and variable stresses and strains due to working cannot be estimated with any reasonable approach to the actual facts. Hence the large factors of safety which are employed in crane work, and which often prove insufficient. In the writer's experience there is no single section of a crane which has not failed under stress, whether cheeks, posts, jibs, chains, tie rods, trucks, both cast and plated, traveller girders, toothed wheels, drums. And these accidents happen not always by reason of want of sufficient strength such as is fairly warranted by past experience, but they are due to the fact that duties of too severe a character are systematically imposed on cranes. Few machines are more ill-used than these; the greatest

sinners being contractors' men, who knock them about unmercifully in order to get through their work to time.

But whatever the difficulties in the way of fixing even approximately on the best factors of safety, careful calculations should be made for new and untried work on a sound basis for those factors in sections where the nature of the strains are sufficiently well known to admit of calculations. Experience must be the controlling guide in other cases.

In an elementary work of this character it is not possible to enter into calculations, but the mode of treatment must be restricted to the description of practical details and of types in actual service from the point of view of the practical man, whether crane maker or user. All crane calculations are applications of the principles and problems laid down in many text-books of statics, to which reference can be made. We will indicate briefly the nature of the problems, and then go on to the practical work of the book.

In crane framings we have perfect applications of the parallelogram, and triangle of forces,—closed chains, in which knowing the nature and direction and magnitude of one force, the nature and direction and magnitude of the others can be measured off graphically. In the travellers and similar cranes we have a simple case of beams supported at both ends and loaded at intermediate points. In balanced cranes the moment of the load, with that due to the overhang of the jib, has to be counterbalanced by a load of equal moment behind. In portable cranes the conditions of stability include that of the truck in addition to the balancing and stability of the superstructure. In one direction this is governed by the length of wheel base, in the other by the gauge, or if that is not sufficiently broad, by extraneous supports, as rail clips, or blocking girders. In some elements, as tie rods, chains, and ropes, the pull is direct, and therefore easily reckoned; in others, as on ground wheels, on roller paths, and on roller rims, the load is purely compressive; in others, as posts, drums, gears, it is partly

correct when the load is lifted on single chain, and the line of same from the head pulley to the drum coincides with the centre of the tie. This is used for various hand and steam cranes, both of fixed and variable radius. The load A runs over a fixed pulley at the top of the jib B, the radius R of which is unalterable except by derricking. No trolley or jenny can run along this crane to vary the radius of the load lifted, hence the reason why many of these are made to derrick ; that is, the jib is hinged at D in order to permit of effecting variations in the radius of lift ;—accomplished both in the derrick cranes proper, and in many ordinary cranes that differ from the true derricks in most details excepting in the capacity for this particular range of movement. This type of framing is very useful, because it gives a good clear head room for work of considerable area and width, combined with a high lift. In modified forms the jibs are bent or cranked inwards in order to increase the area of work that can be swung between the hook and the post.

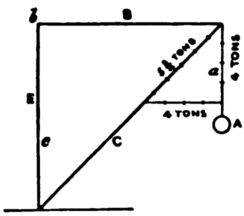

Fig. 2.

In this broad type the pull of the load A is transmitted in tension to the tie rod C, and in compression to the strut or jib B. The loading on the post E mainly tends to break it off as a beam encastre at the ground line, but also slightly to tear it off at the top, an accident which does sometimes happen. The front of the post is in compression, the hinder part in tension.

To estimate the forces or loads on these members in a graphic way, the load due to A is set off in equal parts on the line of pull of the chain *a*, say 4 tons as shown. Lines are drawn at *c* parallel with the tie C, and at *b* parallel with *a*, completing a parallelogram of forces. Points of division equal to that on *a* are drawn on *c* and B. The number of

divisions on c or C to the plane where that line is cut by b is 12, and 12 tons is the tensile load on the tie rods C. The number of divisions on B to where it is cut by c is $14\frac{1}{2}$, which is the compressive load in tons on the jib B. The load or thrust on the post E is 10 tons measured along the line d, the post being a cantilever, since it receives no support from a pivot at the top. The line of the chain from the jib head to the barrel also enters into calculations of this kind, and is of much importance in light cranes and in curved jibs.

The type with horizontal jib, Fig. 2, is one that is very common, being employed for wall cranes, wharf cranes, and many hydraulic cranes. Here there is no tie, properly

Fig. 3.

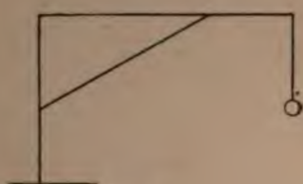

Fig. 4.

speaking, though the jib B appears to fulfil that function. The jib, however, is a beam supported at each end, and loaded to the maximum on the intermediate points if a trolley or jenny is used, and the thrust due to the load is transmitted down from the strut C to the base of the post E. If the load is at the end as shown, a pull of 4 tons on a produces a thrust of $5\frac{3}{4}$ tons on the strut C; and a horizontal thrust of 4 tons on the post at the ground line, under the same conditions of pivoting as in Fig. 1. But in cranes of this kind the jib is usually pivoted at the top as well as at the bottom, and therefore the post is subject to a very small bending moment. And if there is no racking carriage, but a fixed radius only, the jib B is subject

to practically no loading. The principal member then in the framing is the strut C, and the pivots at top and bottom of the post E. Such framings are old favourites because the horizontal position of the jib permits giving a varying radius to the load by the travel or racking of a trolley or jenny along its top edges. The objection to this form is that the strut comes in the way of lifting work of large dimensions at a small radius, hence the design is frequently modified as in Figs. 3 and 4. The first is suitable for a jib of short radius, the second for a long jib. These designs are both suitable for construction in timber, in which

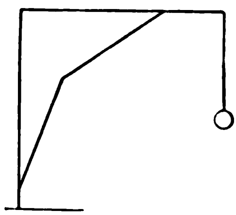

Fig. 5.

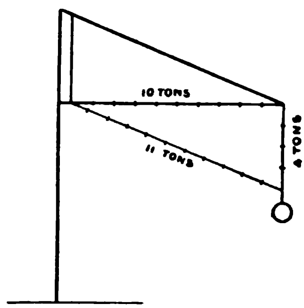

Fig. 6.

they were first made; they are also made in iron and steel with a cranked jib, Fig. 5, which is better than either, but is more practicable in framings that are plated in iron or steel than in timber, though in the latter, a strut can be inserted diagonally between the angles. To get over the objection to the strut, this is often abandoned in favour of an overhead tie as in Fig. 6, which leaves the space beneath the jib absolutely free for handling work at short radii. This is further modified by suppressing the post below the jib, and supporting the jib by an overhead tie as in Fig. 7, and these are not usually connected by a vertical piece, but

the end of each member pivots in a cast-iron bearing which is bolted to the wall, and the wall fulfils the function of a post.

In cranes that are fitted with cheeks or side frames to carry engines and shafting, the post, tie, and jib are still present, but slightly masked. The jib is no longer stepped into the post at or near its centre line, but into a cross

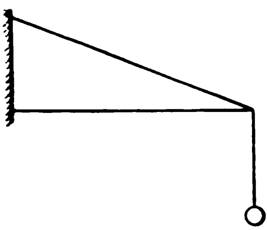

Fig. 7.

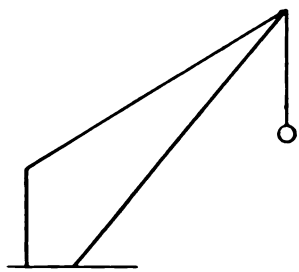

Fig. 8.

girder or a socket situated at some distance out from the post centre, Fig. 8, and directly over the roller path. The essential elements are the same as in other triangular-framed cranes.

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CHAPTER II.

POSTS.

The Function of the Post—Timber Posts—Posts of Iron and Steel with Top Pivots—Self-sustaining Posts—For Fixed and Portable Cranes—Early Posts of Cast Iron—Later Types—Reason why they are being Displaced—Posts of Wrought Iron and Steel—For Fixed Cranes—For Independent Cranes—For Portable Cranes.

THE post, pillar, or mast is a vital element in all triangular-framed cranes, with those few exceptions in which a wall fulfils the function. The stability of a crane depends in the first place on that of the post. If this fails, it will do so either by breaking off at, or near the ground line, where the maximum bending stress occurs in cranes that are supported in a footstep only. In cranes that have top pivots in addition, the post would fail somewhere between the top and bottom pivots,—a determining factor in which would be the locality where the jib happens to be stepped into the post. From this point of view the nearer the jib is brought down to the ground line the better, though having regard to the racking of loads inwards, this is the least favourable position.

Posts are made of timber, cast iron, wrought iron, and steel, either solidly, or built up like girder work. In the simplest examples they are built of two beams of timber united at top and bottom with shoes of cast or wrought iron, in which the pivots are carried. Examples occur in quarry cranes, in the derricks, and in the cranes with horizontal jibs. Timber posts are made of a single balk of timber,

Figs. 9 and 10, or of two sticks. When two timbers are used, they are either parallel, or cambered, and bent over at the top; the first method occurs in some of the larger horizontal jib cranes, the second in the derricks, Fig. 11. The gearing is carried in cheeks bolted to the post. The pivots used are of steel, driven into the top and bottom castings, and these fit into castings, one of which, A, is stepped into the ground, the other, B, bolted to an overhead beam, details which are shown in Figs. 9 and 10 respectively. As the effect of the strains is to displace these castings horizontally, they are secured to stone or timber

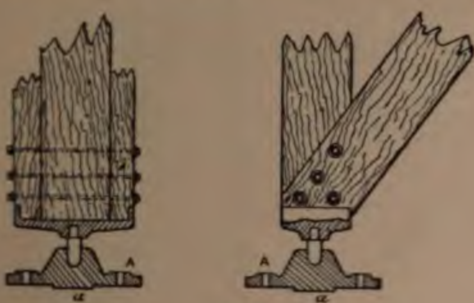


Fig. 9.

below, and to timber above, into which they are joggled by the facings *a a*, or other equivalents. Frequently flanges are cast at the sides of the top plate to embrace the edges of the timber beam, with the same purpose.

The fastenings of the derricks are of a different character, due to the hinging of the jib, and to the overhead beam being replaced by guys which come back to the ground. Details of the derrick castings and pivotings are shown, those for the foot of the mast in Figs. 12-14, and those for the top in Figs. 15 and 16.

Figs. 12 and 13 comprise side and end elevations of the bottom connection. Fig. 14 is a plan of the step or base A.

This is made of large diameter, in order to give an unyielding area to resist pressure, the proportions are massive, and

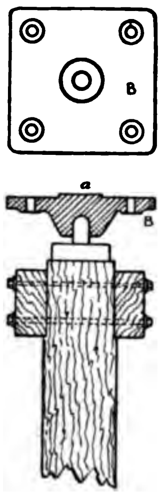


Fig. 10.

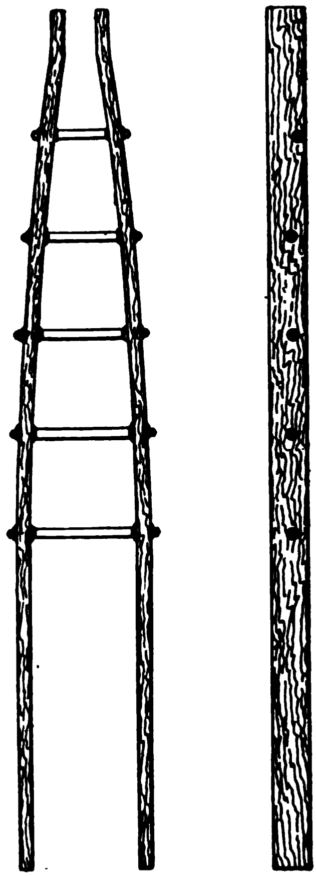


Fig. 11.

strengthening ribs are cast on it. Its boss receives the pin on which the mast turns, and vertical ribs receive the two timber sleepers B B by which the crane is counterbalanced,

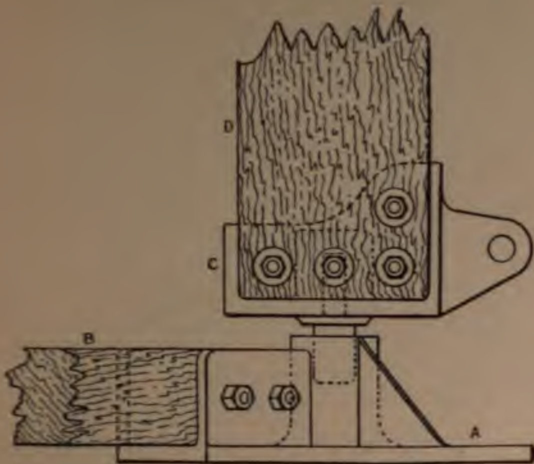


Fig. 12.

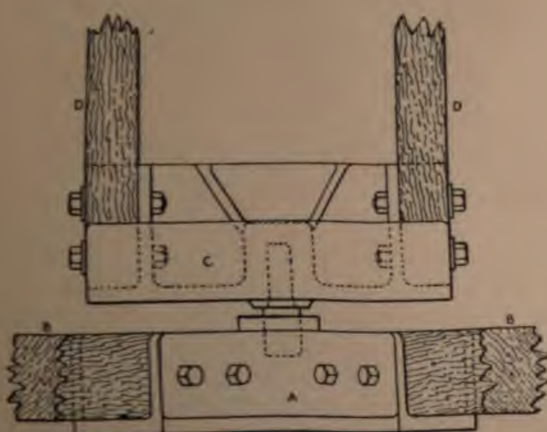


Fig. 13.

and which receive the tensile stresses transmitted through the guys or backstays. Sometimes instead of ribs, a socket is employed. The casting C maintains the timbers D D of the mast at the proper distance apart, and the pin, which is fitted tightly into a hole drilled in its boss, or in cheap derricks is cast in, pivots in the boss in A. The ribs receive a portion of the thrust of the jib, the socket of which is pivoted with a little side play between the lugs in front, on a pin passing through the lugs.

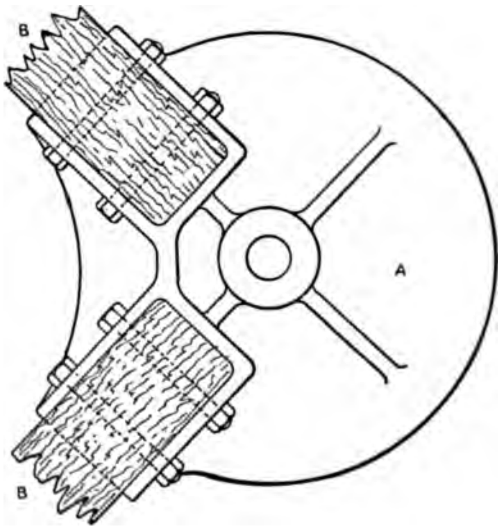


Fig. 14.

The top casting, seen in elevation and in front view at A in Figs. 15 and 16 respectively, maintains the timbers at the right distance apart there—distance pieces being inserted at places intermediate, Fig. 11, p. 12. This casting also carries the two pulleys, for lifting and derricking. At the top of the casting a boss *a*, receives a turned pin B, cottared into it, upon which pin the forgings C C which receive the

ends of the backstays or guys are pivoted at right angles. The cap and cottar above maintain these in place. The metal in these fittings is massive, the stresses being severe in the backstay sockets; the stress on the pulley lugs is tensile, which explains why the metal is massed there.

This type of post, and also that in Figs. 9 and 10, has in a large degree given way to posts of iron and steel built on the same type, particularly in the heavier cranes, in which

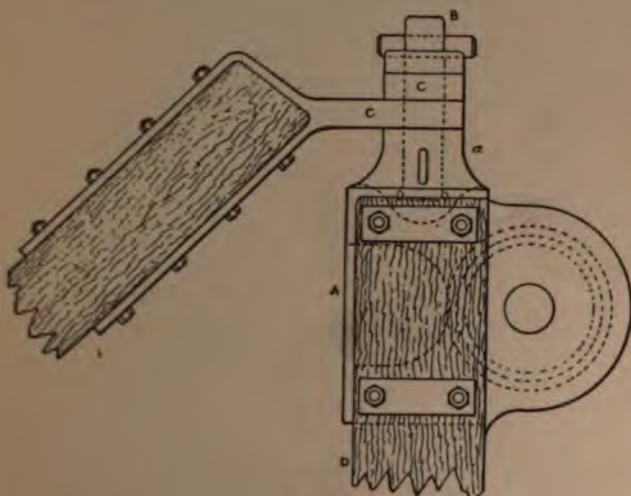


Fig. 15.

two channels, or two lattice-braced beams take the place of the two timber beams. Castings are still necessary at top and bottom for the pins, and castings are bolted on the beams to carry the gearing. Such posts are used for the forge, and foundry, and quarry types of cranes, as well as for the larger derricks.

In by far the larger number of cranes made, the post cannot be supported with a top pivot, but must be self-

contained and self-sustaining, being either pivoted in its base in rare cases only, or fixed in its base. Then the total effect of the stress both of the crane and its maximum load at maximum radius has to be calculated as a bending moment across the section at the ground line, or the line from which the cantilever starts. In many cases, as in the portable cranes, the post goes down but a few inches lower than this—sufficient to secure it in its step; but in many of the fixed cranes, as in those of the wharf type, it descends several feet below into a foundation socket, or step. In either case the ideal form is that of a cubical parabola.

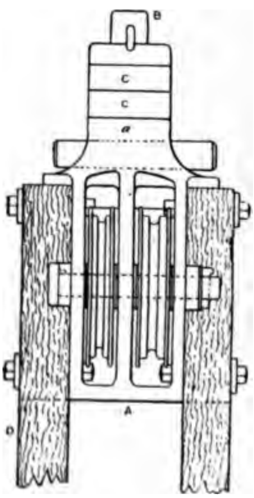


Fig. 16.

The earliest self-sustaining posts were of cast iron, and a very early and persistent form comprised post and cheeks cast in one, a type which, though nearly obsolete now, has nevertheless many points in its favour. The great objection to it was that the post was largely in tension, the most unfavourable for cast iron; yet all the hinder portion from the ground upwards and the lugs for the tie rods were in that condition of strain. Consequently many of these broke off at different periods at various sections from the ground line upwards, in spite of the fact that the metal was $\frac{1}{4}$ in. or more thicker at the back than the front.

After these came the circular post of cast iron, Fig. 17, a type used much for wharf and warehouse cranes, ranging in power from about 15 tons down to 1 ton. The attachments are made in various ways to such posts as these. In the smaller sizes of a ton or two of power, the jib may be

stepped into lugs cast on the post just above the ground line, the post in this case slewing along with the jib. In the larger sizes a roller frame, p. 65, generally encircles the post just above the ground line round the turned belt, and the jib, of iron or timber, is stepped into this. The frame is sustained

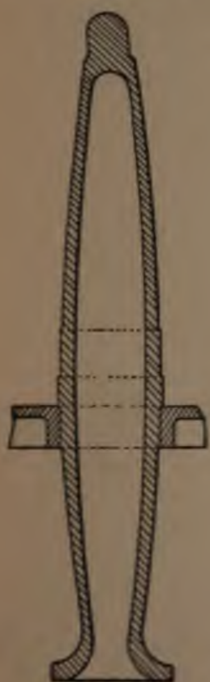


Fig. 17.

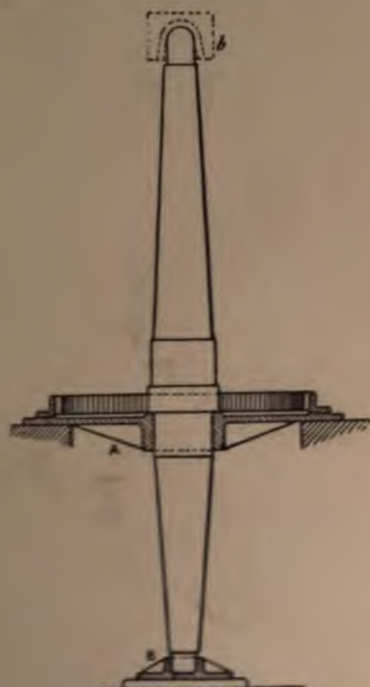


Fig. 18.

in the vertical direction by tension rods coming down from a cross-head, p. 63, fitting over the top of the post. An immense number of cranes have been constructed in this way, in powers ranging from 3 tons to 10 and 15 tons upwards, for railway sidings, wharfs, and warehouses.

Posts of cast iron have not proved very reliable, many cases of fracture having occurred, even though the metal has been from 2½ to 3 in. thick, at and near the ground line, in 6 ton, and in 10 ton cranes respectively. These posts are cast horizontally, and the metal along the top is often liable to be a little spongy and open; to compensate for which an extra ¼ in. of thickness has been often added there. An advantage in cast iron in the lighter class of warehouse cranes is that lugs and cross-heads can be cast in one with the post more cheaply than they can be afterwards fitted. Against this must be set the drawback that the fracture of a lug involves throwing the whole post on the scrap heap. These are sufficient explanations of the fact that cast iron has been largely displaced in favour, first of wrought, and later of steel for posts.

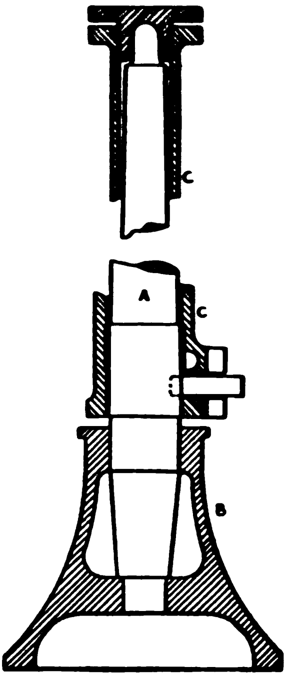


Fig. 19.

Fig. 18 illustrates a solid post of wrought iron or steel, as used in a fixed wharf or ware house crane. Here the post is sustained at the ground line in a base plate A, within the boss of which it is keyed, and the foot is carried in a footstep casting B stepped into a foundation plate in the larger cranes, see Chapter VI., pp. 76 and 79, both plates being of cast iron. An immense number of such posts are in use. They cost more than those of cast iron, though the difference is less now than formerly, thanks to the use of mild steel, but

they are absolutely reliable. The steel works supply the rough forgings, which have then only to be turned round the belt where the post fits into the plate A, round the roller belt, at the bottom, and at the top on which the cross-head rotates, the position of which is indicated at *b*.

In a special kind of warehouse crane,—the independent type, in which there is no deep foundation, the post A, of wrought iron or steel, Fig. 19, is stepped into a casting B with a spreading base of from 3 to 4 ft. in diameter. An outer sleeve C,—not the true post,—though it appears to be so externally, encircles this and carries the rollers round the belt, and the top drum and tie rods.

Fig. 20.

In portable cranes in which the post cannot come lower than the truck, the construction shown in Figs. 20, 21 is employed. Fig. 20 is made in cast iron, Fig. 21 in wrought iron or steel, but for the reasons just given the employment of cast iron is diminishing. The writer has known several cases of fracture of these near the top at the part encircled by the cross-head. A post of wrought iron or steel can also be made smaller in diameter than one of cast iron, which gives more room for other details. The post shown in Fig. 21 has a hole through it, which is necessary to permit of the passage of the vertical shaft by which, through gears, the travelling motion is imparted to the crane. The hole is bored through the solid post with D-bits, boring from each end. The ends are bushed with brass to take the vertical shaft. Posts are fastened into their trucks or foundation plates partly by making a press fit, partly by reinforcement with keys, or with set screws, Fig. 22.

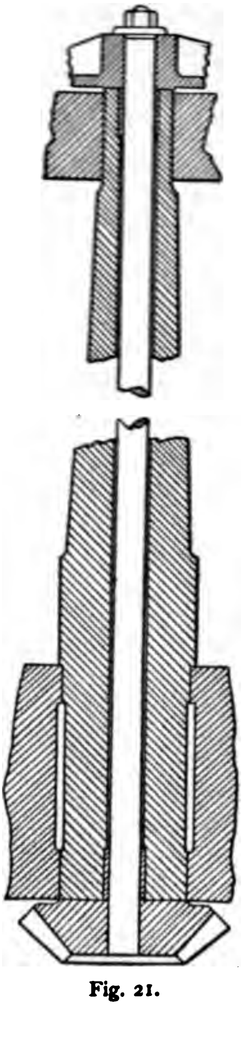


Fig. 21.

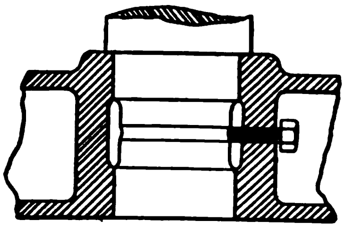


Fig. 22.

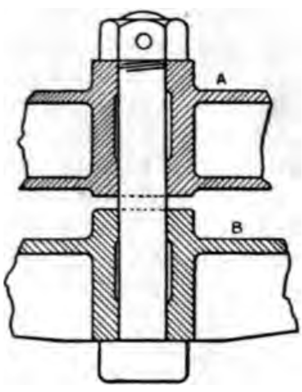


Fig. 23.

In the horizontal cranes, and in the Titans the post is reduced to a mere pin, or pivot, Fig. 23, connecting the revolving superstructure A to the travelling base or truck B; the weight of A is taken on a ring of rollers between A and B.

In the steel derricks the post or mast is built of rolled channel sections, with angles, and lattice braced, as in Fig. 24.

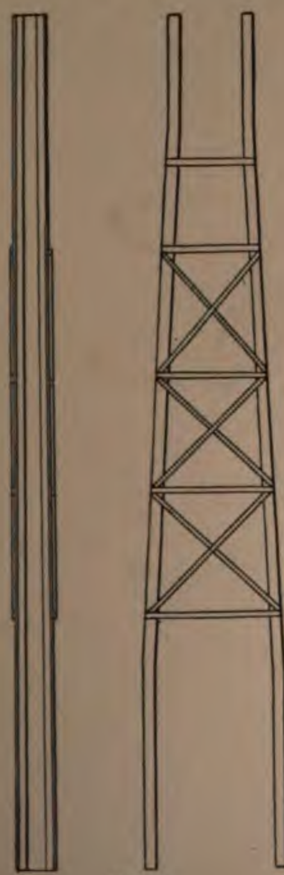


Fig. 24.

CHAPTER III.

JIBS, STRUTS, AND TIES.

The Broad Types of Jibs—Cantilever Jibs—Fairbairn Jib—Strutted Jibs—Jibs with Ties—Stresses—Timber Jibs—The Single Member—Socket Fittings—Double Timbers—Their Fittings—Horizontal Jibs—Jibs of Iron or Steel—Raking Jibs—Forms of Construction, and Bracing—Straight, Cranked, and Bent Types—Fittings—Tie Rods—Stresses—Method of Attachment—Shoe Castings—Pulleys—Pins—Derricking Chains—Movable Jibs—Screwed Ends, and Eyes.

JIBS, struts, and ties are grouped together because they are mutually dependent. A jib, with a few exceptions, is not self-supporting, but is sustained by ties, or with struts. From this point of view various forms of jibs become grouped naturally under three broad types—the cantilever, the strut supported, and the tie supported. The first are not numerous, the second only moderately so, the greater number of examples come under the last-named head.

Cantilever jibs are used chiefly on some forms of long-armed cranes, usually of the travelling type, with or without provision for rotation, as on the Brown cranes and related types, and on some Titan cranes. Having no extraneous support they are built of girders of semi-parabolic outline, Fig. 25,—semi-parabolic, because a trolley has to run along them, and therefore a level track is necessary. These girders may be likened to a parabola divided down the longitudinal axis, the two halves being placed side by side with the hoisting chain or rope hanging down between. The girders are sometimes solid plated, but much more often lattice braced, as being a lighter and equally strong form of structure. The combined weight of the girders and

trolley, along with that of the load lifted, is counterbalanced by the loading at the rear, on the other side of the centre *a—a* of the crane, where boilers and engines, with extra ballast is also located, if required. Or two cantilever arms, as in some of the Brown cranes, counterbalance each other.

These cantilever cranes are usually of longer radius than other types, too long either for a raking jib to be utilised, or a strutted jib. Their function is chiefly that of loading various materials over large areas. The radius ranges from 50 to 100 ft. in various examples, over which length the trolley is racked anywhere from at or near the centre of the crane, picking up and travelling the load. When such cranes are fitted also with a travelling motion, as is almost invariably done, and with a slewing movement, which is frequent, the range covered is very large. The value of these cranes,—

Fig. 25.

outside the Titans, which are used specifically for setting concrete blocks for submarine work, in breakwaters, piers, and moles,—lies in the following applications :—Loading and unloading vessels and railway trucks with various materials, as ore, coal, spoil, and other cargo. Loading and unloading steel and iron plates and bars in yards. Handling plates and sections in shipbuilders' work, the cranes then spanning the slip-ways and covering two vessels to right and left of the same track. Besides these there are other miscellaneous services of the more general character rendered.

There is one particular form of the cantilever jib which does not carry a trolley—the Fairbairn type. It is a bent cantilever, entirely self-sustaining by virtue of its strong construction, which is that of a solid-plated or braced box girder of approximately rectangular section.

The jib which is sustained by a strut is generally of the horizontal form, a form which in a number of cases is alternatively supported by ties. A raking jib is also a strut because subject to compressive loads. But a strutted jib of the horizontal form is not only subject to compression, but to bending, the particular kind of bending being governed by the position of the strut, and the location at which the load is lifted. If the strut meets the jib at a considerable distance inwards and the load is lifted at the end, the overhanging portion of the jib will be subject to bending as a short cantilever. If the jib has a racking carriage, then the load being hoisted at any positions intermediate with the end and the post will produce bending moments, the intensity of which will vary with position, but the calculations will be made for maximum stress midway between supports.

Jibs with ties,—the most numerous and important section,—include examples from cranes of the shortest to the longest range made, from the little wall, and warehouse cranes to many Titans, and Temperley transporters, and immense wharf cranes. The method of supporting a jib by ties or tension rods, or chains has the merit of simplicity. The jib is much lighter, conditions being equal, than when it has to be self-supporting, and the absence of struts leaves the maximum head-room possible beneath, while in jibs of great length struts cannot be used, but the alternative is a heavy cantilever.

In crane jibs of the raking type, and in struts, the stress is theoretically considered as compressive. But owing to their great length they must be taken as coming under the head of long columns that would fail by bending. A jib never ruptures by crushing, but failure by bending is not infrequent, an accident to which this member is specially liable by reason of the rapid slewing motion. This is often performed at a high speed when a crane is fully loaded, so putting a heavy side strain on the jib. This member therefore bends in this direction more frequently than it does in

the vertical, a fact which is amply provided against in the best designs.

The simplest and oldest jibs are of timber. They are chiefly used in the wharf cranes, in the horizontal jib type of cranes, and in the derricks. In some of these of the raking type they consist of a single stick of timber only,

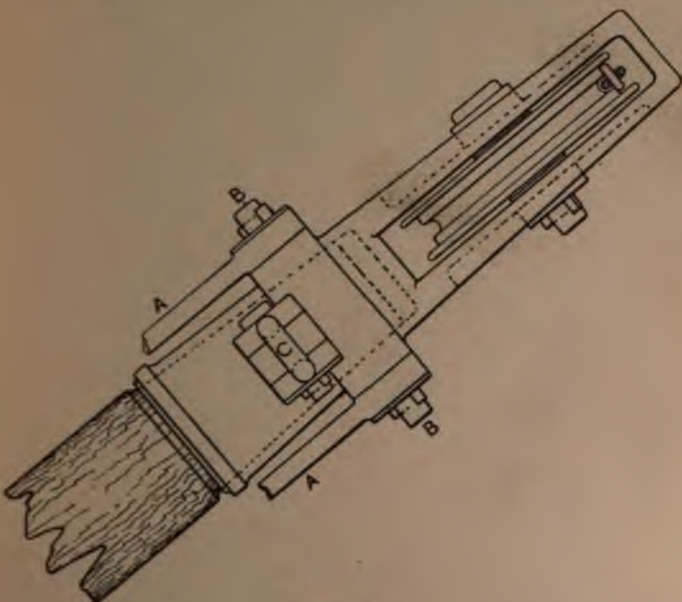
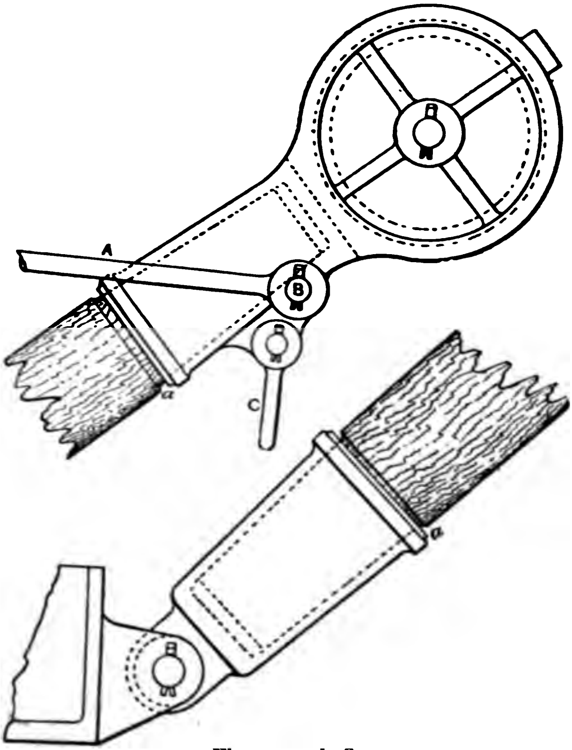


Fig. 26.

of square or circular section, but in most cases two timbers are used. Timber jibs formed of a single stick are either of circular or octagonal section, and they taper down from the centre to the ends, forming a rough approximation to two parabolas meeting at their larger ends. The castings that form the sockets for feet and head correspond in shape, having octagonal, square, or circular recesses. Often

an octagonal jib is cut circularly at the ends to enter circular sockets. When a single stick of timber is used, stepped into sockets at top and bottom; the first named, shown in Figs. 26 and 27 in plan and elevation, carries the



Figs. 27 and 28.

chain pulley; the second, Fig. 28, fits by a pin between the lugs or sockets cast either on the crane cheeks, or the roller frame, or the footstep cast to receive it. The bottom pin is in shear, loaded with the full load transmitted down the jib. The pulley pin is generally in shear, but if two or

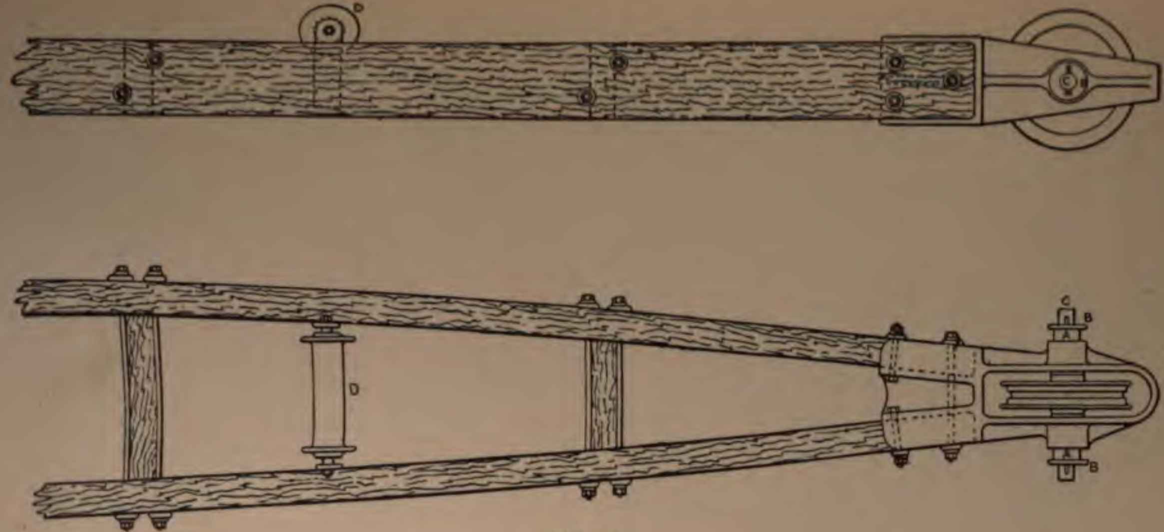


Fig. 29.

more pulleys are on one pin, the pin is subject to bending. It may or may not transmit the full load on the jib. In Fig. 27, for instance, a good portion goes through the tie-rod pin, while in Fig. 29 the compression goes to the jib through the casting, and the pin does not feel it.

The sockets are castings tapered to receive the tapered ends of the jib, over which they are driven with sledges. The object of rounding the edges of the mouths is to avoid sharp angles in the timber at the shoulders *a*, which would be a source of weakness there. The timber ends should be well saturated with thick white lead paint before insertion as a preservative against dampness, the great enemy of timber. A jib begins to decay from this cause in the sockets before it does elsewhere. At the first driving, the timber does not go right to the bottom, because a little shrinkage is almost sure to occur in time, and it is desirable that the fitting should never become loose.

The single piece of timber occurs in many of the derricks, and in certain types of wharf cranes, the two timbers in the larger derricks and wharf cranes, and in horizontal jibs.

When two timbers are employed they are either parallel or cambered;—parallel when the jib is horizontal, as happens in most cases, when the trolley runs along on the top of them, and the chain falls between. They are cambered in some wharf cranes. The two timbers are stepped into a socketed casting that encircles the iron post; and are connected at the top with another casting, Fig. 29, that receives the chain pulley. The gearing is then carried in cheeks, Fig. 51, p. 53, that are bolted to the jib at a convenient height above the ground line. Distance pieces maintain the timbers at the proper distance apart. Such a jib is well adapted to resist the lateral stresses that occur during rapid slewing.

The horizontal type of timber jib consists of two pieces arranged parallel with a clear space between. They are maintained at their proper distance apart at the ends only, to allow clear room for the racking of the lifting chain to

various radii. At the rear end they are shouldered into the mast and connected therewith by means of bolts, see Fig. 10, p. 12; at the front end they rest on shoulders cut in the ends of the strut timbers, and a distance piece there maintains them at their proper position asunder. Rails are bolted on the top edges to take the flanged wheels of the racking carriage or jenny, and brackets are bolted on at each end for the chain pulleys.

Timber is not, however, suitable for very large cranes, and its employment has diminished since the introduction of mild steel has given us large rolled sections. Timber jibs are seldom used on cranes of over 5 tons power, occasionally they are put on 10-ton cranes. It is most suitable on cranes of a few hundredweights capacity; and red deal, pitch pine, or oak are used.

Timber-framed cranes with horizontal jibs and raking struts are not safe and suitable for foundry and forge service, and these are therefore generally built up of steel plate and angle. The three members,—post, jib, and strut,—are flush jointed, with covering plates riveted over the joints, and the inner and outer edges are stiffened by the riveting of angle sections all round.

In some cheap, light, hand warehouse cranes the jib is simply a round bar of iron about 2 in. in diameter, curved, and the post and tie are formed of similar bars. The jib is supported about the centre by a bar strut, or by struts formed of a ring or rings of iron. In another simple form the jib is made of two flat bars of iron bent, and the post is similarly formed. In both cases distance pieces maintain the bars at the proper distance apart. In some small and cheap cranes a single I joist section only forms the jib, being stepped into castings at top and bottom, into which they fit loosely in the first place, and are secured with iron cement, the design of the single timber jib being embodied in metal.

After these, the simplest jibs of iron or steel are built of

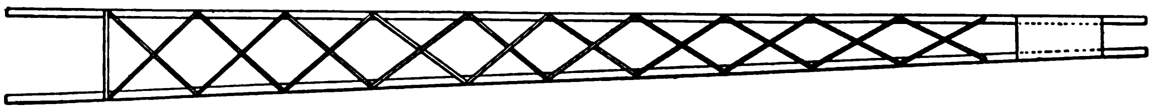


Fig. 34.

Fig. 35.

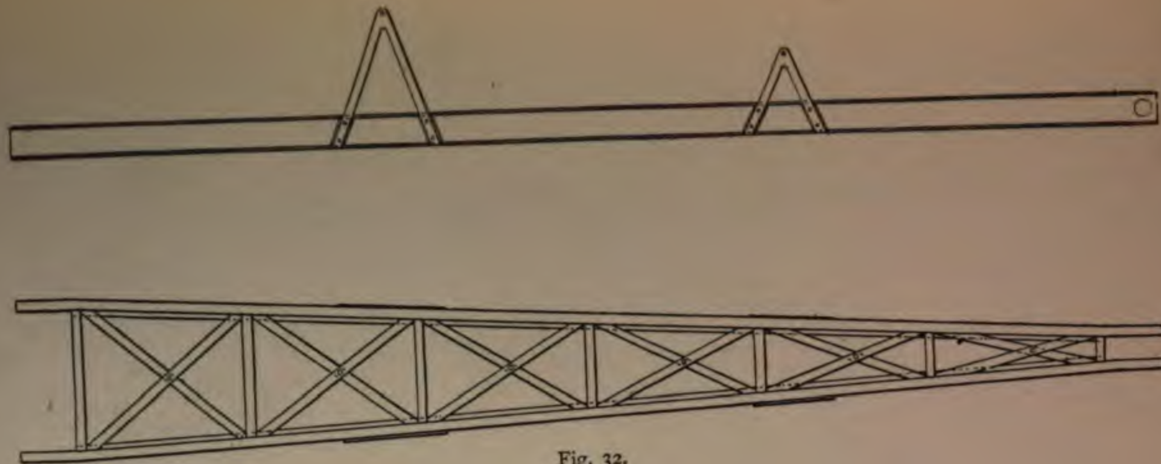


Fig. 32.

Fig. 33.

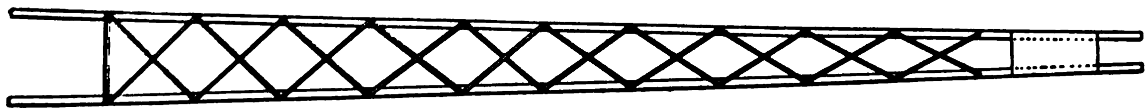


Fig. 34.

Fig. 35.

the rolled channels, or I sections, Figs. 32, 33, which form the jib sides. These are liable to twist, and therefore in most cases double bracing, Fig. 34, is riveted to both flanges of the channels or I sections. These are well adapted for light cranes either of long or short radius. In stronger and heavier types the rolled sections give way to

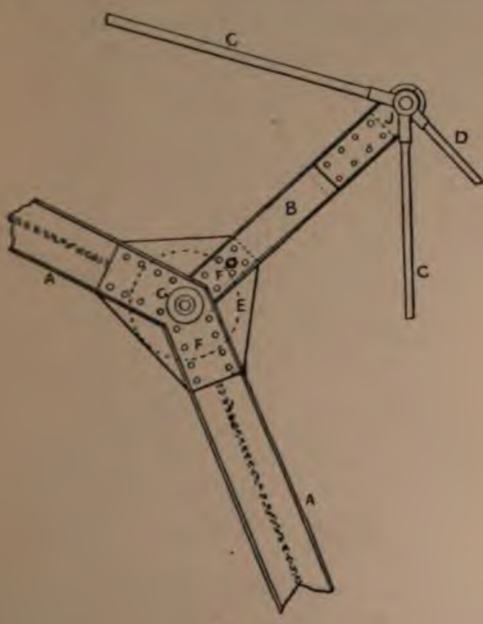


Fig. 36.

forms built up entirely of angles and bracing bars, so imparting a rectangular cross section, either square or oblong to the jib. Fig. 35 is a derrick jib of steel built up in this way. Lastly, the straight raking jib gives place to a form that provides more head-room and area for lifting;—the cranked jib, Figs. 36 and 37, or the bent or cambered,

Fig. 38. The first is rather cheaper, but it has to be strutted, while the bent jib is self-sustained.

The cranked jib, the strutting of which is shown in Fig. 36, and the jointing to a larger scale in Fig. 37, is more easily made than the bent type. It resembles traveller girders constructed of timber or of parallel steel joists, see Chapter VIII., p. 99, in the fact that the strains are transmitted from the jib A through the strut B to the tension rods C C, going to the jib foot and head respectively, and D going to the

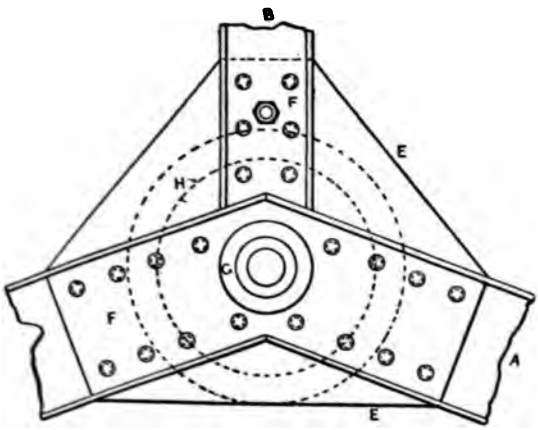


Fig. 37.

head of the side frames. These connections must therefore be strong and well made. The jointing is with a broad gusset plate E covering the joints of A A, B, and castings F fitting in the channel sections; castings, joists, and gusset plates being all riveted up together. A boss G on the large casting forms the bearing for the pin of the pulley H, which conducts the chain or rope from the lifting drum to the pulley at the jib head. This pulley H fits freely on its pin—sliding along it from one side to the other as the chain or rope winds from end to end of its drum. A casting J, or a

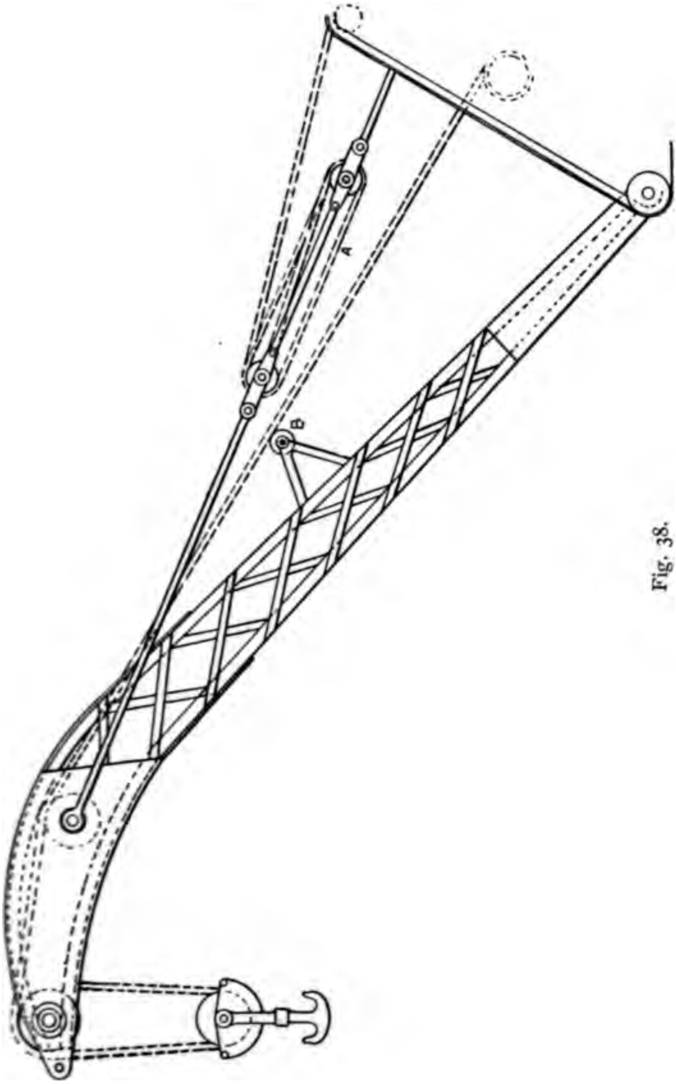


Fig. 38.

forging is fitted into the head of the strut B to take the pin over which the tension rods are looped.

The bent jib, Fig. 38, is of a composite type in which the fitting of the tie rods at some distance away from the end leaves the portion between the anchorage and the foot in compression, while the length beyond the anchorage is subject to bending as a cantilever. The jib is widened at the dividing section to afford strength to the cantilever end. The cutting of the hole for the pin and its boss does not sensibly weaken the section, since this metal is removed at and near the neutral axis.

Here, where four angles have to be bent and each pair of bracings differs in length and in angle from the others, it is easy to get the jib atwist unless the work is done carefully. It is marked out to actual size on a floor, and measurements taken direct, and the bending checked therefrom. At top and bottom the angles are united and stiffened with broad plates riveted to them, and castings are fitted within these to receive the pins for the foot, for the lifting, and the guide pulleys respectively. This is a derricking jib, to which further reference will be made directly.

The fittings of iron and steel jibs are generally cast, in some cases they are forged. They consist of brackets, feet, or shoes, pulley, pin, and tie rod bearings,—varied much with the class of crane. They are mainly in compression, and supported more or less by the framing.

In many cases the bottom casting serves the function of a roller box, which may or may not pivot, depending on whether the jib derricks or not (see Chapter V., pp. 66 and 67). The top casting often contains the jib pulley, more often separate castings are employed, details of which are shown in subsequent figures.

The function of the jib is to carry the pulley or pulleys over which the chain or rope passes from the hoisting drum to the hook. The shapes of pulleys are illustrated in

Chapter XIII., p. 164, but the method of rigging them up belongs properly to the present section. As, however, they are often carried in the same castings as those to which the tie rods are anchored, and as the fitting of the pulleys and tie rods are taken in hand simultaneously, we will postpone remarks relative to the pulley fittings until the methods of attachment of tie rods, to be now considered, have been disposed of.

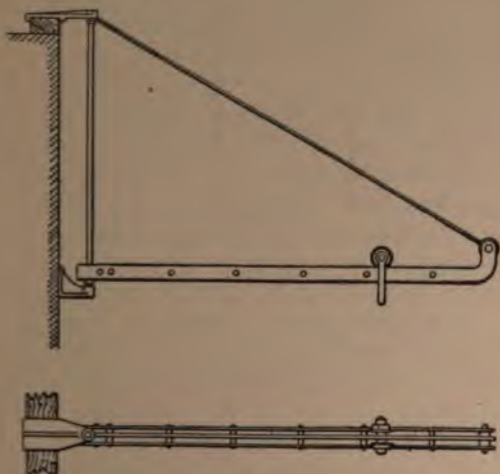


Fig. 39.

Tie rods are variously arranged. In jibs of average length one pair of ties suffices. In those of great length more are necessary to support the jib both at the ends and at intermediate positions, and the king posts necessary for their attachment have to stand up to a great height in order to get an angle large enough from the horizontal for a proper transmission of the tensile stress.

The simplest tie is that shown in Fig. 39, in which one tie rod supports a bar, used as a smith's crane,

fitted in these castings, and recesses are cored out to receive the pulleys. These occur in the derricks, Fig. 26, p. 25,

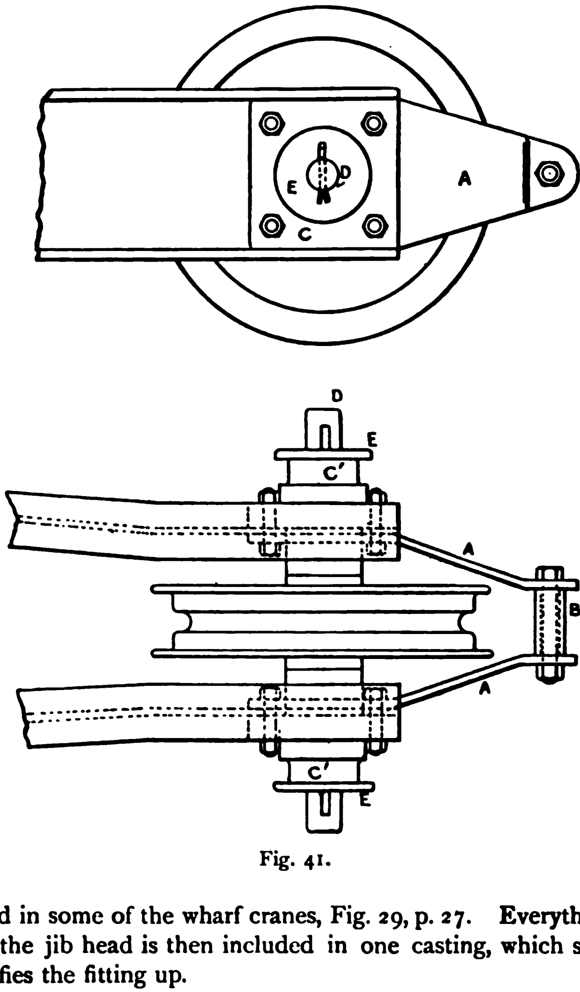


Fig. 41.

and in some of the wharf cranes, Fig. 29, p. 27. Everything at the jib head is then included in one casting, which simplifies the fitting up.

In some cases a single casting at top, and one at bottom unites the sides of a steel jib, but generally separate ones are used for each cheek. Fig. 40 illustrates one type of jib-foot casting, fitted within the channel A, or to a built-up section. The hole encircles a turned boss on the front roller frame which fits between the crane cheeks, see Fig. 74, p. 67. It is equally suitable for a fixed or a derricking jib. The bearing is divided with a cap, but many of this class have the hole bored in the solid. The lug shown in Fig. 40 receives the tension rod, coming down from the strut of a bent jib.

In jibs built of sections, or of angles and lattice bracing, it is not usual to make the jib-head casting do duty for all fittings. There may in some cases be several castings, as the pulley bearings, with which the tie-rod anchorages are included, besides which there are other castings for the anchorage of the bight of the chain when a snatch or return block is used. If the jib is cranked, or curved, the tie-rod anchorages are quite distinct from the pulley bearings, being fixed in a different position, see Fig. 38, p. 35.

Fig. 41 shows a simple jib-head fitting for a chain pulley. Two pieces of steel plate A A are bolted between the H sections, and cranked to receive a distance piece B, which also prevents the chain from jumping outside the pulley. Two castings C′ C′ are fitted outside, and bolts pass through A and C′, which are bored in place to receive the pulley pin D. The castings are prolonged into bosses C′, over which the tie-rod eyes fit, and on which they are retained sideways with washers E E. Frequently instead of fitting separate plates A A, in the manner shown, the jib sides are extended, and the flanges cut away to the distance to which A A extend beyond the end of the actual jib, and the web is set over to receive the distance piece. In many cases also castings are fitted instead of the steel plates.

When the lifting chain or rope comes to the jib pulley in a horizontal line, unless of considerable length, the jib

carries no supporting rollers. But when the chain or rope comes up in a line parallel or nearly so with the jib, the sag of the chain is taken on loose rollers in bearings fixed to the jib. The same device is necessary in jibs that are cranked or bent. A roller is seen at B in Fig. 38, p. 35, and at D in Fig. 29, p. 27, while the fitting of two brackets to carry rollers is seen in Fig. 32, p. 31.

A detail of jib fitting is the shackle to which the chain or rope is hooked when lifting with a snatch or return block. The shackle C, Figs. 26 and 27, pp. 25 and 26, is hung from a pin which passes through one lug, or through a pair of plates. The first is the usual method of attachment in timber jibs. The lug must be long and strong, the cast iron being in simple tension. The second is adopted when the jib is built up of rolled sections, or of angles and bracing.

When a jib is made to derrick, two rigid rods are generally attached at one end with eyes to the jib-head castings,—an example of which occurs in Fig. 38, p. 35. At the other they are furnished with looped forgings to embrace pulleys, and receive the pulley pins. The pulleys receive the derricking chains A that come from the derrick barrel within the crane frames.

With few exceptions jibs and ties are rigidly fixed to the post. The exceptions occur in many of the light hydraulic cranes. In these the ends of the jib and tie next the post are fitted with rollers, which ascend or descend on the post under the control of the lifting cylinder.

When tension rods are screwed at one end, as they are in overhead travelling cranes, and in some timber-framed jib cranes, it is most important to keep the bottom of the screw threads full to the size of the plain portion of the rod. In the case of eyes, the cross section on each side of the hole must be somewhat in excess of half that of the rod. Eyes are generally welded to their rods after the forging and tooling has been done. For this reason iron is preferable to steel for eyes and rods.

CHAPTER IV.

CHEEKS.

Cast or Plated—Variety in Detail—Strains—Outlines—Cast Cheeks—Crab Framing—Frames of "Vertical" Type—Their Weak Points—Details—Frames of "Horizontal" Types—Crab Cheeks—Cheeks attached to Timber—Steel-Plated Cheeks—The Bearings of Cheeks—Solid and Divided Bearings—Bearings Cast with their Cheeks—Those attached to Plated Cheeks—Disadvantages of Solid Bearings—Several Bearings in one Casting.

THE cheeks of cranes are subject to great variations in design. In small cranes they are of cast iron, in heavy ones, steel plated. But many small cranes are cheaply made with steel plate, while for permanent way cranes, this type is always employed. Plated work is much cheaper than formerly, and is more reliable than castings. But castings still cost less, because the bearings are in one with the frame, while in plated work the bearings must be prepared separately, and bolted or riveted on. But these are often cheaply fitted in the form of round bosses in place of the more expensive divided bearings.

Cheeks are generally made separately, and united with distance pieces. But in some cranes, as the horizontals, they are bolted down to the revolving bed, in others they are cast in one piece with it. Cheeks are single plated and ribbed, on one or on both faces in most cranes, but in the heaviest they are sometimes of the boxed form, being cored out.

The strains on frames are not usually calculated. They are subjected to all kinds of stresses in working, tension,

compression, side strain, vibration, &c., which cannot be properly estimated. A firm's own experience furnishes the data necessary for thicknesses. Frames have been broken, and thickened up in the weak parts, shrinkage stresses have to be avoided, and in this tentative way safe and standard

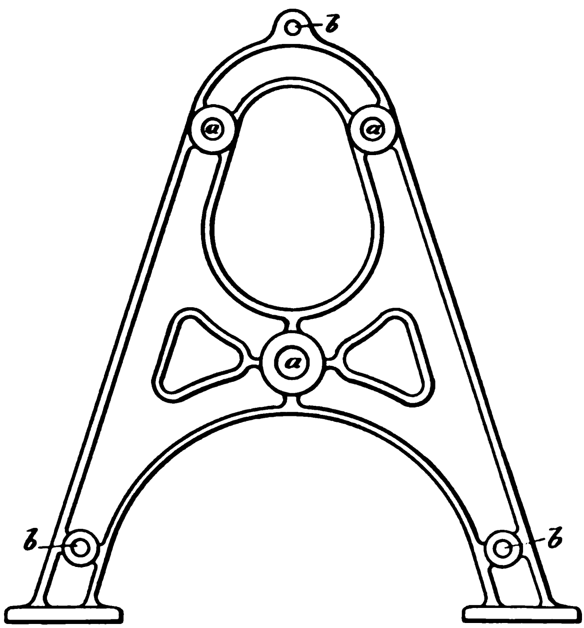


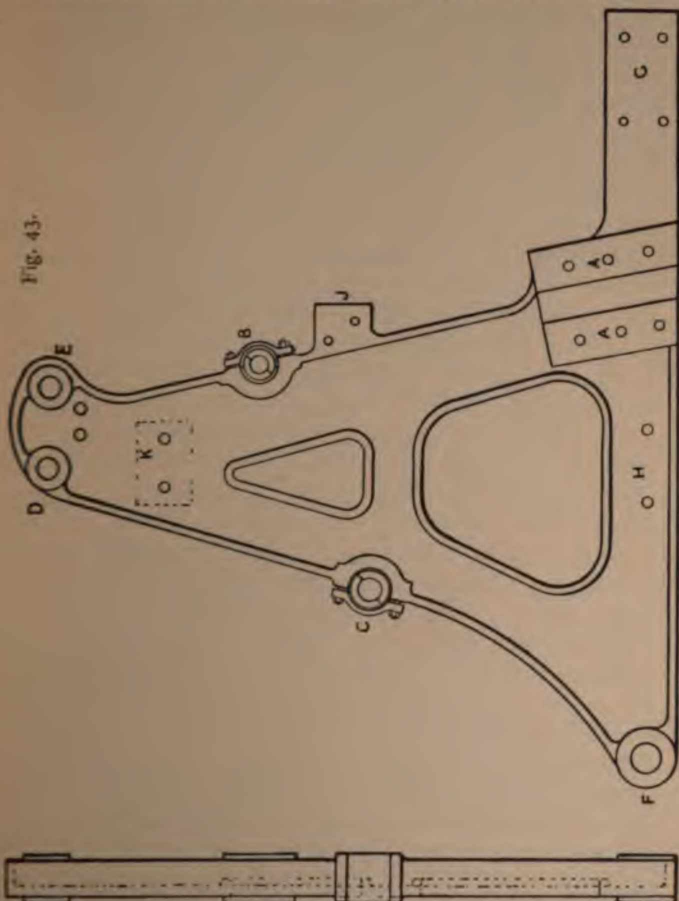
Fig. 42.

proportions are evolved for cranes of different powers and radii.

There is no standard shape for frames, apart from a firm's own practice. The centres of the shafts give the main outlines. These centres being fixed by the gearing, control the main dimensions, and the rest is a matter of strength and taste. Curved outlines are often imparted to castings,

but plain ones to plated work. The parabolic curves of some horizontals are neat and tasteful. A frames are common

Fig. 43.



in verticals and in hand crabs, and rectangular frames in power crabs. Balance cranes have a tail prolonged behind the cheeks to carry the balance box. These are sometimes

cast in one with cast cheeks, but are better if made of rolled channels and bolted to the cast frames. In plated cheeks they are formed of plate and angle like the other parts.

The following are the principal designs of cast-iron cheeks :—

The simplest self-contained cheeks, that is, those which are independent of extraneous support, not being fitted in any fashion to plated or timber work, are found in the common crabs and winches, that are bolted down to timbers, and in which the bearings are solid, *i.e.*, formed by drilling holes in bosses cast in the frames. The typical crab framing is A shaped, Fig. 42, very light and flimsy, being sold cheaply, and used for hand work only. The weak web is stiffened with fillets cast around the edges on both sides. In the common class of frames the shafts run directly in the iron bearings, *a*, *a*, *a*, in a better kind the holes are brass bushed, which is desirable because the bushes can be easily renewed when they wear. The distance pieces by which the frames are kept at their proper distance apart are simply round double-ended bolts with collars or shoulders, passing through the holes *b*, *b*, *b*, so that there is little rigidity in these frames away from the timbers to which they are bolted.

The cheeks of the cranes proper are either of high, or low type, namely, "vertical" or "horizontal" respectively. Taking the verticals first, these are built with some approximation to the A shape, Figs. 43, 44, but much modified in the various classes of cranes which are designed. They are large, ranging from about 4 ft., to 7 or 8 ft. in height, and from $\frac{1}{2}$ to $1\frac{1}{4}$ in. thickness in the web. They are ribbed on one side only,—the outside, or on both sides, the choice being a matter of taste. The bearings are nearly invariably of the divided type. Even when bearings come within the frame, a recess is often cast for the fitting of the cap and brass. Brasses are usually fitted, exceptions occurring in some of the cheaper hand cranes. The frames are used in conjunction with a central post, see Chapter II.,

pp. 17, 19, and 20, and are maintained at the proper distance apart by cross girders, which fulfil other functions, as that

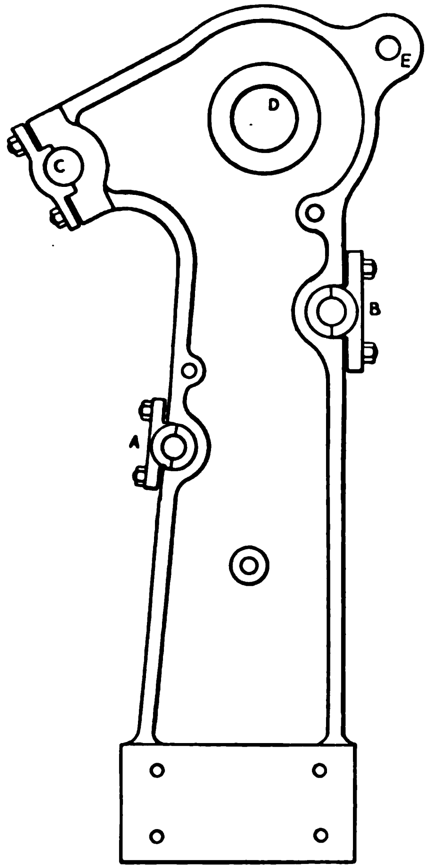


Fig. 44.

of roller frames for slewing the entire superstructure round the post, jib sockets, &c., and as post heads, taking and trans-

mitting the load of the revolving superstructure to the post. Facings are cast on the inner sides of the cheeks or side frames to receive these cross girders, the ends of the latter and the facings being planed, and turned bolts unite them in one rigid framework which rotates round the post. The lower edges of the cheeks come at a few inches' distance above the base, or truck.

There are certain parts of these frames which are severely stressed, those most liable to fracture being the upper part of the frame to which the tie rod is attached, and the front lower portion that receives the pressure of the front roller. A good many fractures of these two kinds have come under the writer's observation. A good plan is to thicken the metal over these areas, making it $\frac{1}{4}$ in. thicker there than elsewhere, and shaving it down to merge gradually into the general thickness. Another section which is strained severely is the area around the barrel shaft, also in tension, in front of the shaft, by an amount equivalent to the direct pull of the load.

The cheek in Fig. 43, p. 45, belongs to a steam crane; A A being the facings on which the cylinder foot is bolted, B is the bearing for the engine shaft, C that for the hoisting barrel, D that for the worm wheel and barrel used for derricking, E that for the anchorage of the rear tie rods which come to the tail of the crane, F is the bearing for the front roller frame over the curb ring. Three other frames or cross girders are bolted between the cheeks, at G carrying the back roll, at H with the two centre rolls, at J the girder from which the engine shaft clutches and gears are manipulated, and K which receives the top of the post, and the anchorage of the derricking chains. The bolt holes for these girders are indicated.

Fig. 44, p. 47, is a cheek for a light hand crane. A and B are the bearings for the first and second motion shafts respectively, and C that for the barrel Two cross pieces only unite the frames, one embracing the broad face at

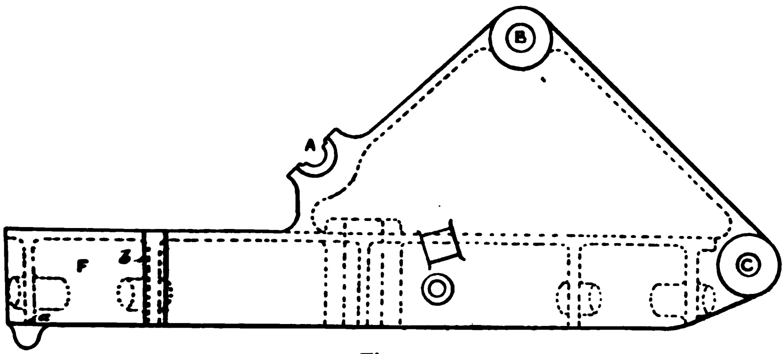


Fig. 45.

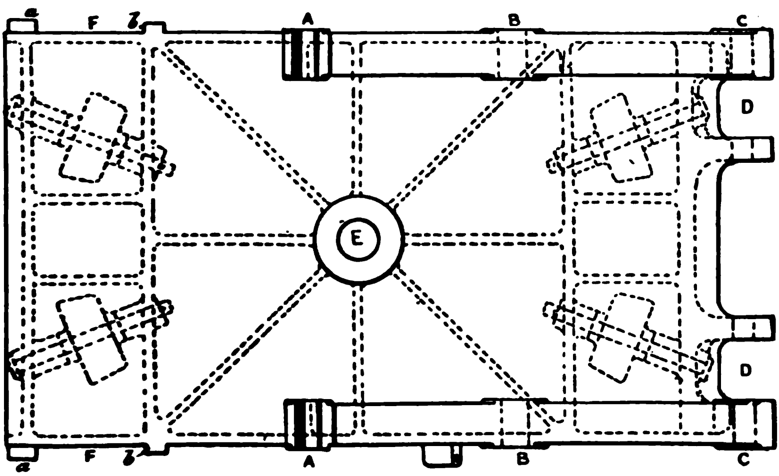


Fig. 46.

the bottom, the other fitting into the hole D near the top. E is the lug for the anchorage of the jib tie rod.

In what are termed the horizontal, or low type of cranes, only applied to steam cranes, and to electrical ones built on the same model, the frames are considerably reduced in height, and are cast in one with the roller frames, except in the more powerful cranes. The alteration in height affects the design further;—as in setting the engines horizontally, and bringing the gears low down, which involves lengthening the superstructure at the rear to receive the engines and their connections. One of these

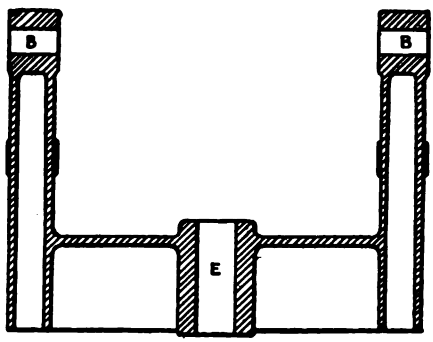


Fig. 47.

frames is seen in Figs. 45-47 in elevation, plan, and cross section respectively. We here get a cored-out bed as the basis of the small cheeks, with which the cheeks are either cast solidly, or not uncommonly bolted on. The cheeks have sometimes been ribbed only, as indicated in plan in Fig. 46, but in all good designs they are cored out as in Fig. 47, leaving smooth plated faces both on inside and outside. Some of the later designs in this class of crane are very neat and graceful.

In Figs. 45-47, A is the engine shaft bearing, B that for the barrel shaft, C that for the pin which carries the jib foot.

The jib feet fit between the spaces D D. The superstructure revolves round a pin in the hole B of the central boss. The faces F F receive the tail girders which rest on the lugs *a*, and come up against the abutment strips *b*. The frame runs on the four rollers seen dotted in the plan view.

Cheeks of cast iron are used for hand crabs, one being illustrated in Fig. 48. The first motion shaft is at A, the second at B, and the barrel shaft at D. E E carry the axles for the trolley wheels, and F is the bearing for the hand shaft, by which the trolley wheel beneath is actuated through gearing. The metal is thickened in the vicinity of D and

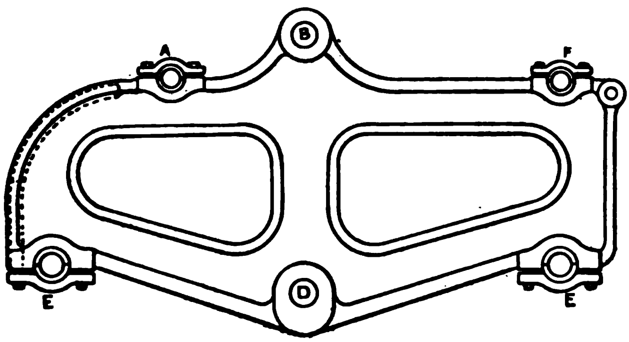


Fig. 48.

below the hole where it is in tension, which cast iron is ill adapted to resist.

Cast-iron cheeks which are not independent, but are attached to timber, are illustrated in Figs. 49 to 52. Fig. 49 is extremely simple, and is found on the posts of triangular-framed cranes, carrying the barrel. The castings are abutted only against the timber, and the bolts pass right through the latter. To prevent the cheeks from becoming shifted, a joggle is usually cast to fit into a mortice cut in the timber, so assisting the bolts. This method of fitting is as a rule only suitable for hand cranes.

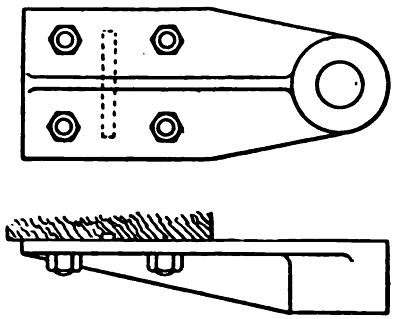


Fig. 49.

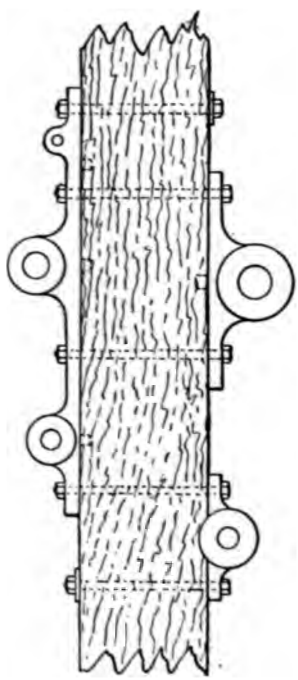


Fig. 50.

Fig. 50 is a method of fitting taken from the mast of a derrick crane. The bearings are merely dead eyes bolted

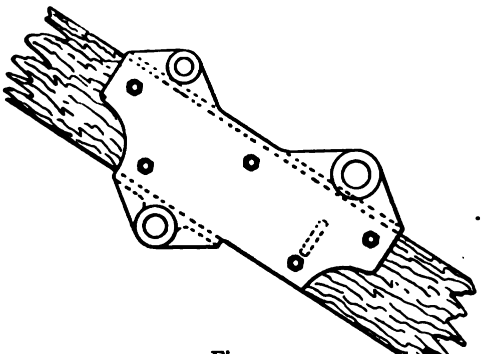


Fig. 51.

on the edges of the mast timbers. They carry the gear shafts, and the shafts for the derricking and the lifting barrels. Joggles are cast on to assist the holding power of the bolts.

Fig. 51 is a cheek which embraces the jib timbers of a wharf or quarry crane, and carries the first and second motion shafts, and the barrel shaft; Fig. 52 is a bracket that is bolted to a wall to carry the single gears and drum, used for light cranes of the smithy and foundry types. The crane jib, see Fig. 39, p. 37, is entirely disconnected therefrom.

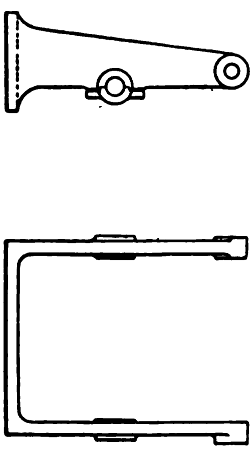


Fig. 52.

The second class of cheeks, those made of steel plate, are designed in various styles, though plated work does not admit of so many diversities in form as cast does.

case angles are riveted to the plates, and the meeting corners should be welded, and not abutted merely.

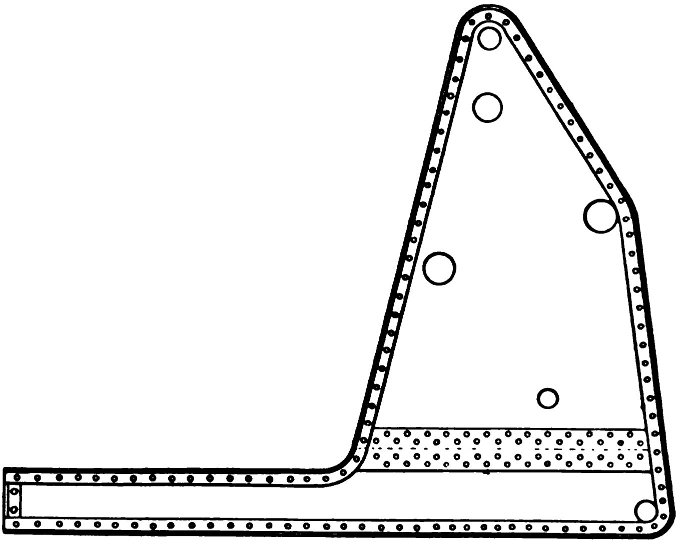


Fig. 56.

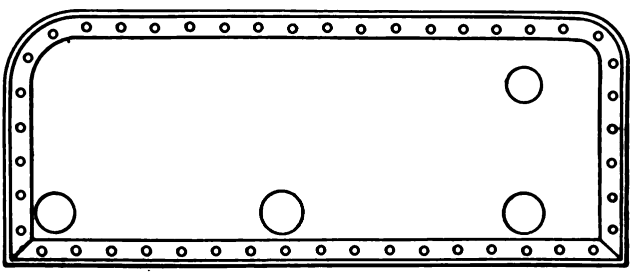


Fig. 57.

The bearings for the shafts differ in form when they are cast with cheeks, or bolted to plated frames. Taking the first named, examples of solid bearings or dead eyes are

seen in Figs. 42, 45, 48, 49, 50, 51. But the divided bearings are preferable, and these are usually of a simple type, details

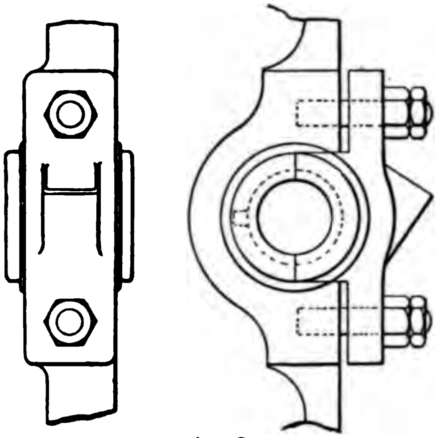


Fig. 58.

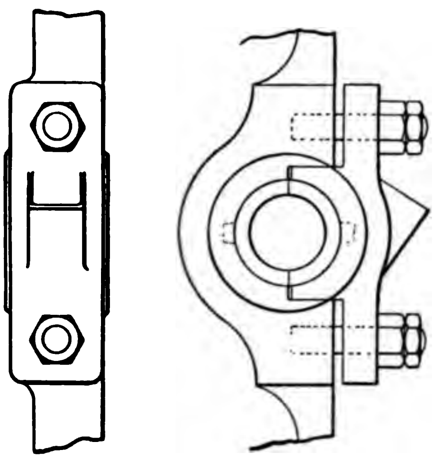


Fig. 59.

of which are seen in Figs. 58-60, each of which is fitted with brasses, which is usual in good practice.

In Fig. 58 the brasses have shoulders or flanges. To prevent them turning round in their circular seatings, a stud is cast on one brass, entering into a drilled hole in its seating. An oil cup is cast on the cap. Studs are used to hold the cap down. In Fig. 59 the brasses have no flanges. Both, therefore, have studs to prevent them from sliding endwise. In Fig. 60, the cap has no check, but abuts simply on the face of the bearing, and the brasses are divided at

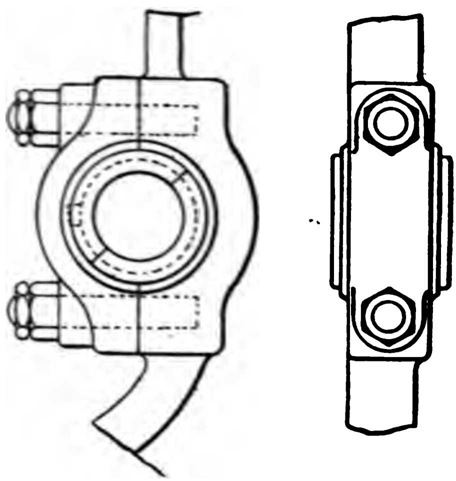


Fig. 60.

an angle. In many bearings the top brass is square, and the cap is a plain plate of steel, a design which is adopted for many heavy bearings in high-class work.

The cast bearings fitted to plated cheeks are variously made. The following are the principal methods which are adopted for fitting such bearings.

The simplest occur chiefly in hand cranes, and consist of a cast-iron boss of circular or other shape, bolted to the face of the cheek, and partly recessed into it, as in Fig. 61,

a ring being turned on the casting of about the same thickness as the plate, to fit the hole bored in the plate.

Such bearings cannot become displaced. The only objection to their use is that no provision exists for closing them round their shafts to compensate for wear. But as they are generally brass bushed, as shown in Fig. 61, it is easy to renew the bushes.

There is a second objection, which, however, carries weight chiefly in the larger, more complicated cranes. It is that the shafts can only be withdrawn from their bearings endwise, when pinions or other parts require renewal, and the loss of time involved thus causes inconvenience. In the

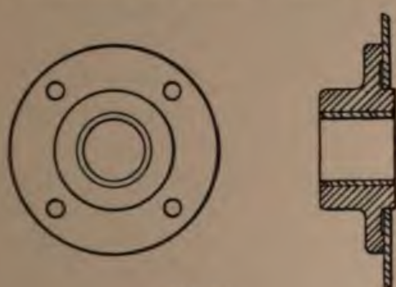


Fig. 61.

better class of cranes, therefore, when single bearings are attached to plated work, provision is made for adjusting bearings and removing shafts by means of caps and brasses. The pattern bearing is first fitted round the angle iron which forms the edge or fillet of the plate, and the casting is bolted both through the angle and the plate. If bolts are used for the caps instead of studs, the holes are cored to get the recesses for the heads, and reamered for the stems of the bolts.

Fig. 62 shows a circular bearing fitted near the edge of a frame, as in the top, or the bottom. This has to be fitted round the angle, instead of cutting away the latter, which of

course would be inadmissible. Fig. 63 shows a bearing fitted against an angle at a straight length, as for a winch, or barrel shaft. The boss still goes through the plate, as in other cases, to assist in steadying the casting.

Frequently it is practicable to include two or more adjacent bearings in one casting bolted to the edge of a plated cheek. This method is extended in other cases to

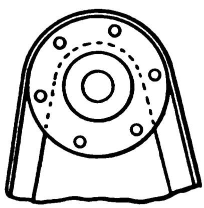


Fig. 62.

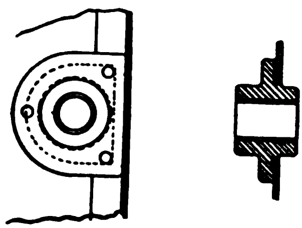


Fig. 63.

the casting of cheeks to include all the bearings required, this case being paralleled by those cases previously illustrated embracing a post or jib of timber, or plated, an alternative to bolting castings on opposite edges. In some instances again large cheeks, quite distinct from the rest of the crane, carry all the gears, and the cheeks are reduced to horizontal channels, or built-up sections of channel or H section.

CHAPTER V.

STRETCHERS, CROSS GIRDERS, ROLLER FRAMES, AND ROLLERS.

Functions of Cross Girders—The Case of Horizontal Cranes—Fitting of Girders and Cheeks—The different kinds of Girders—Post Heads—Roller Frames—The Single Frame—Separate Frames or Boxes—Front Roller Box—Back Roller Frame—Centre Roller Frame—Rings of Live Rollers.

THE larger cheeks, whether of cast iron, or plated, have to be maintained at a definite distance apart by stretchers or cross girders, some of which also fulfil the function of frames or bearings for the rollers by which the slewing is performed. It is seldom that a simple stretcher is used without utilising it also for some other function, if only to carry a boss for a lever. The simplest stretchers are the round bolts used for maintaining the sides of small crabs apart. With this exception, most, excepting those on some of the heaviest cranes, are of cast iron.

As stretchers, or girders, and cheeks should form a practically solid whole, slewing as one piece, this is ensured by excellence of fitting together. An exception occurs in the horizontal cranes in which the cheeks and roller frames are usually in one casting, see Fig. 46, p. 49, though in some of these when of heavy type the roller frames are made separately from the cheeks.

When cheeks are bolted up to cross girders, the ends of the latter are planed to fit against planed faces on the cheeks, and turned bolts passing through reamered holes

connect them. From the point of view of workmanship, it is desirable and is usual to make all the cross girders for

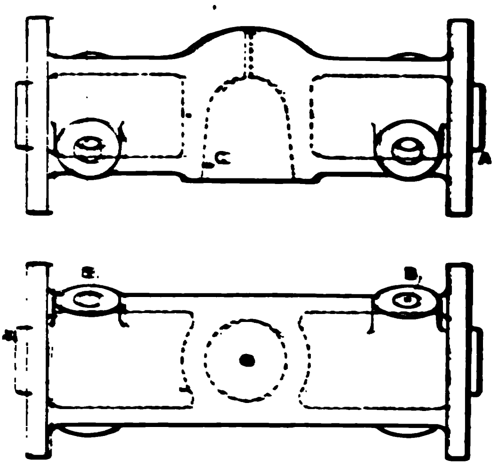


Fig. 64.

a crane of the same exact length, and their facings on the frames all of the same height. The girders are then planed in a row at one operation, and the facings planed at one setting of the tool, in another operation, so that no resetting of work or tools are necessary.

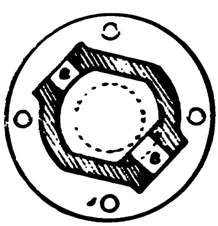


Fig. 65.

An average crane may require from two to four or five cross girders. Thus, the cheeks in Fig. 44, p. 47, require two, those in Fig. 43, five, neither of which is a plain stretcher, but fulfils some other duty. The principal girders in a crane are the post head, and the roller boxes. The first has the weight of the superstructure to carry on the post in some cases. In others the load is carried entirely on the rollers, and

the post head simply steadies the top of the crane, and transmits the transverse strain or pulling strain of the crane to the post head. Sometimes tie rods pass through the post-head girder, which affords them a good anchorage.

Figs. 64 and 65 illustrate a post head which sustains the entire weight of the superstructure, and receives the two tie rods that go to the head of the jib. It fits the side frames in Fig. 44, p. 47, the studs A A at the ends entering

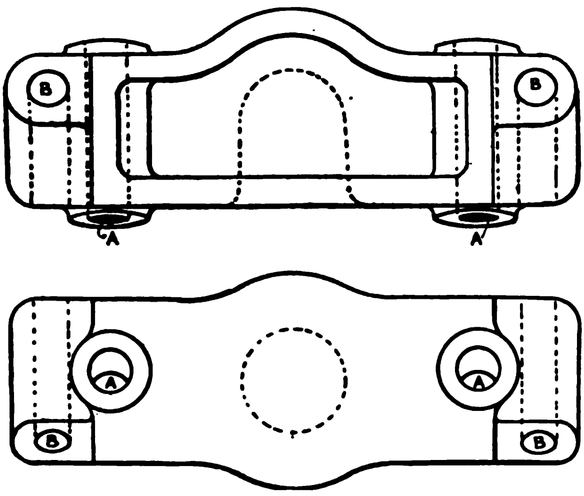


Fig. 66.

the holes D in the side frames, and bolts unite the head and frames through the round flanges. B B are the holes for the tie rods, which pass easily through them, with not less than $\frac{1}{8}$ in. clearance, C is the hole into which the top of the post enters, and having a hole above for lubrication.

Figs. 66, 67 illustrate another of a different class, though of the same type, namely, that which sustains the weight of the crane. This crane has no side frames, but the cheeks and gears are on the post, and the latter is stepped into a

roller casting that encircles the base of the post, see Figs. 17 and 18, p. 17, and turns round it. This casting is sustained by tie rods passing through the holes A A in Figs. 66 and 67, and is hung therefore from the post, while two rollers in front are the means by which it slews. The holes B B receive the tie rods going to the jib head. Fig. 68 is the centre of a post head in which the weight is partially taken on the roller path. The head encircles the post, but there is no great pressure on the end. More often instead of using a loose plate like that shown above, the hole for the post is cored only a part of the way through the girder, but this leaves no means of compensation as the rollers and path wear down.

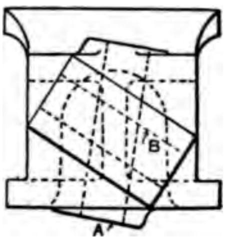


Fig. 67.

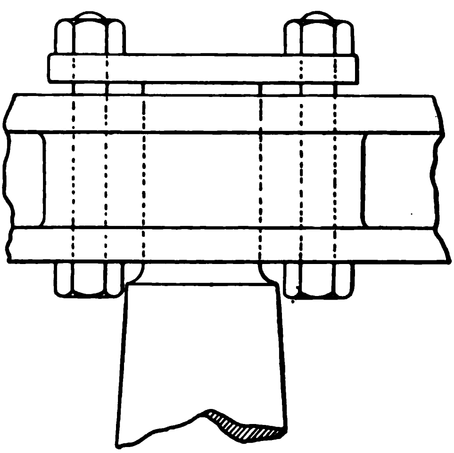


Fig. 68.

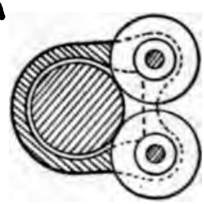


Fig. 69.

Rollers are carried in frames or cross girders of varied patterns. Fig. 69 shows a case in which no separate frame

is used, the roller pins fitting into lugs cast in the post, the latter being illustrated in Fig. 19, p. 18.

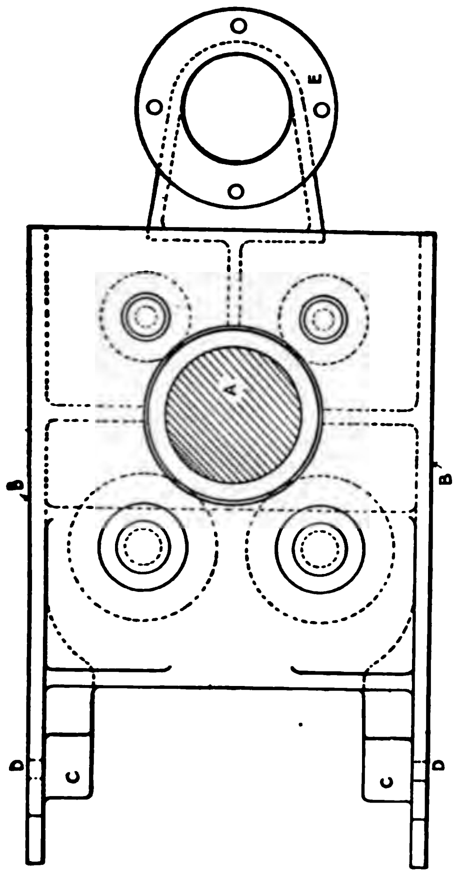


Fig. 70.

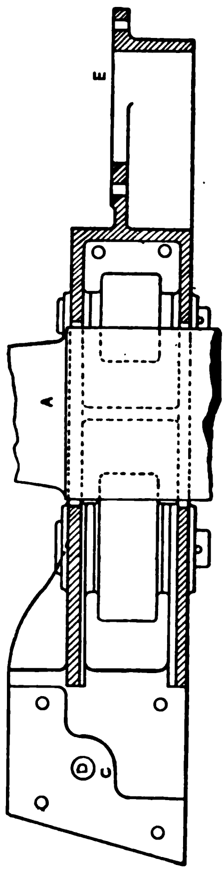


Fig. 71.

In the simplest cranes one roller frame suffices, in the larger sizes three or four frames are required. Figs. 70, 71

illustrate one of the first-named type, carrying four rollers, running round the post A, so that in this case the weight of the crane is sustained on the top of the post.

This frame fits between its side frames by the faces B B.

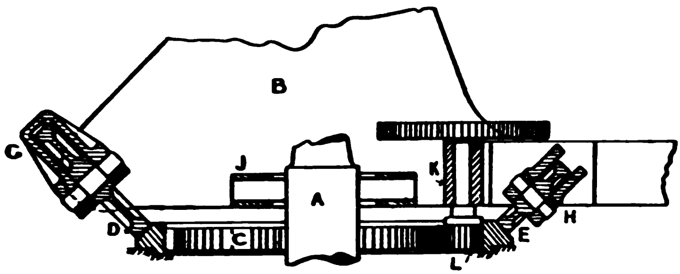


Fig. 72.

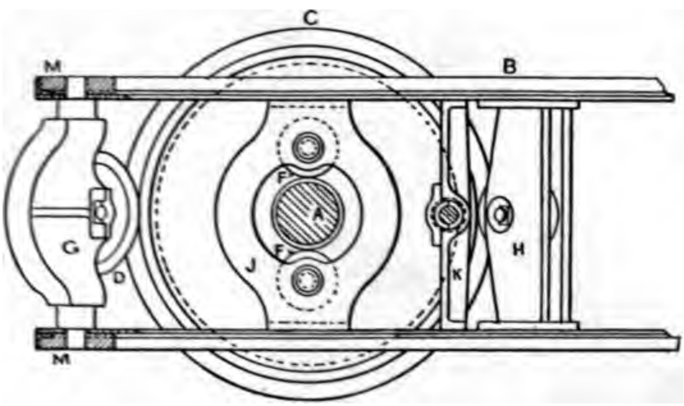


Fig. 73.

The jib feet are socketed into the seatings C C, which receive the thrust due to the load; pins that pass through the holes D D simply prevent the feet from movement in their sockets, and do not take any stress. At the hinder end a flanged

bracket E is cast with the frame to receive the foot of a standard which carries bevel gears for slewing the crane.

The second-named type, that in which more than one roller frame is required, occurs in the larger cranes. A common example is shown in Figs. 72, 73, in vertical section, and in plan respectively. In these Figs. A is the post, B B are the cheeks, and C the roller path and curb ring combined. There are four rollers, the front D, the back one E, and the side rolls F F. D and E travel on the roller path, F F steady the crane round the post. In larger cranes

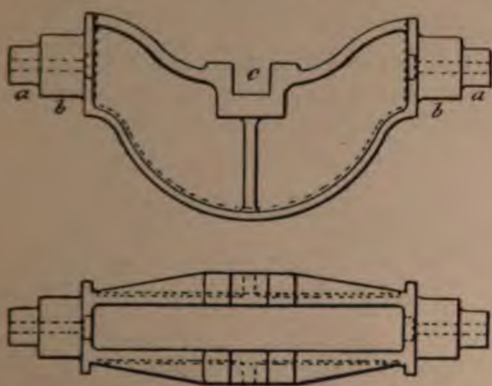


Fig. 74.

side rollers often run on the path also, but on its flat upper face. The three roller frames are indicated by the letters G, H, and J; being front, back, and middle respectively. The girder K is a combined stretcher, and bearing for the shaft of the pinion L, that engages with the curb ring C.

The front roller D receives practically the whole of the stress. Its frame or box G is shown separately in Fig. 74. Its turned trunnion ends *a a* enter the cast-iron bearings M M in Fig. 73, which are riveted to the steel frames, but cast with cast frames, as at F in Fig. 43, p. 45. The necks

marked *b b* are encircled by the jib feet, one form of which is illustrated in Fig. 40, p. 39. The interior of the box G is cored out to take the roller, the journal of which runs in brasses fitted into the square seatings *c c*.

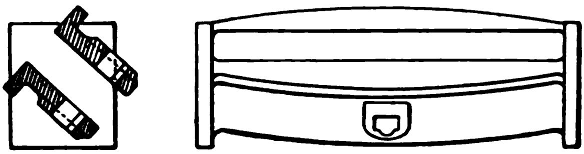


Fig. 75.

The back roller frame H, is shown in Fig. 75. It is bolted by its flanges between the side frames, and the roller either runs in plain bored holes, or in a top brass, the space for which is seen cored in Fig. 75.

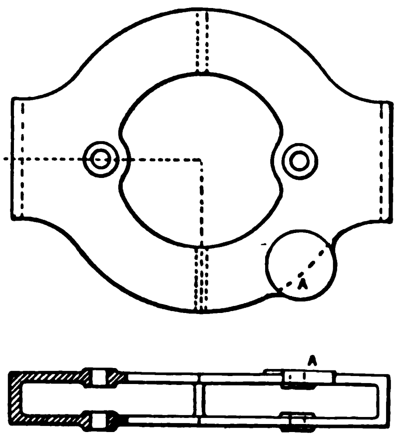


Fig. 76.

The centre roll frame J is seen in Fig. 76. It carries two rollers, the pins for which fit in the holes in the axis of the casting. A facing is shown at A, to receive a bearing for

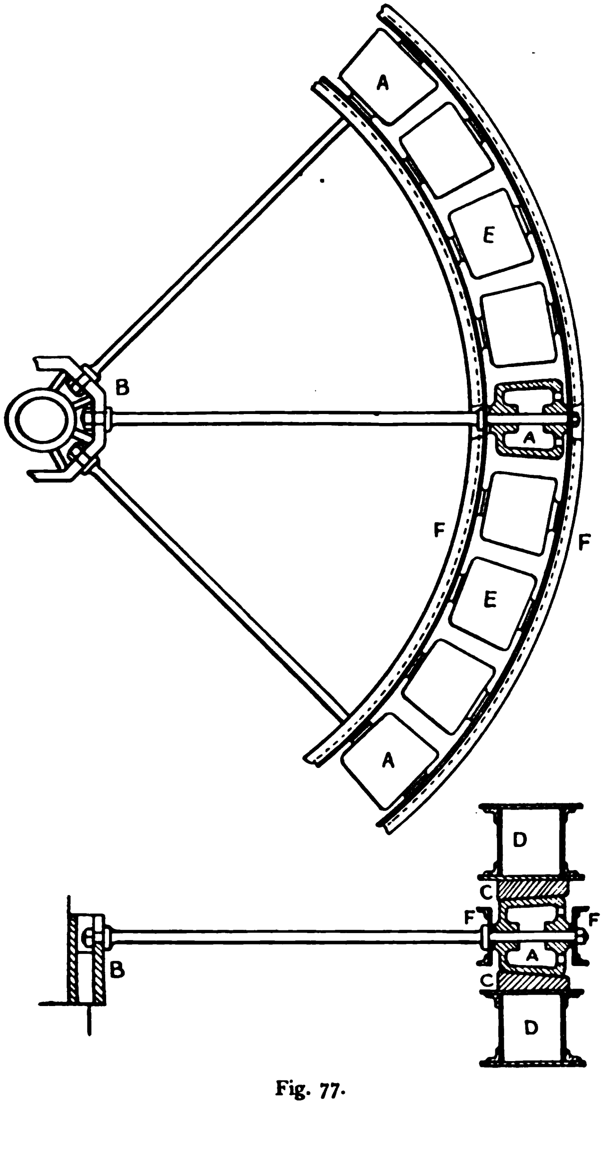


Fig. 77.

a slewing pinion, this arrangement not being illustrated in the general view, Fig. 73.

Stretchers which do not serve the purpose of heads to posts, or frames for rollers, carry lever bosses for sliding gears on engine shafts, and other minor functions.

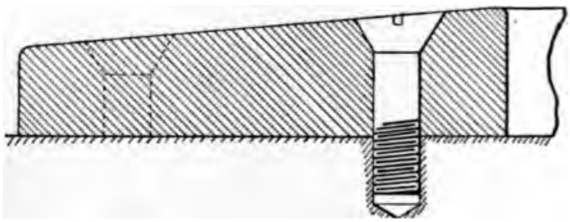


Fig. 78.

In the largest cranes of all, roller frames are abandoned, and rings of live rollers running between paths of conical section take their places. Fig. 77 shows this arrangement as applied to a Titan crane. The main rollers A revolve on

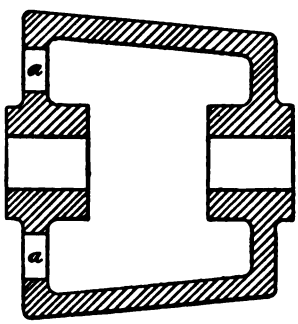


Fig. 79.

the ends of the radial rods, which are fastened to a centre casting B, and the rollers run between the paths C C, screwed to the top and bottom circular girders D D. Intermediate rollers E are simply carried between the rings F F, which maintain them in proper radial relations. An enlarged

section of a path is shown in Fig. 78, and one of a roller in Fig. 79. The path is formed of steel bar bent to the circle. It should properly be turned after bending, but when no lathe large enough is available, such paths are planed to a bevel first, and curved afterwards. The rollers are iron, or steel castings, and the holes shown at *a a*, of which there are four, are for getting the core out through. Only large

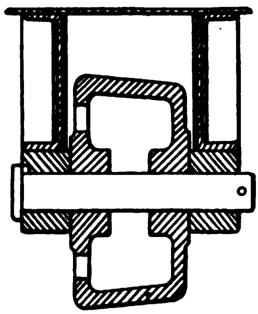


Fig. 80.

rollers are cored out thus, those of medium diameter being dished in the way seen at D E, in Fig. 72. Those of small diameter are solid discs, as in Fig. 71.

Sometimes cranes of large dimensions have a bottom roller path only, and then the rollers may be carried as in Fig. 80, in bearings attached to a circular girder. They are cast hollow, and revolve on their pins, which are prevented from rotating by a nib next the collar.

CHAPTER VI.

THE BASES OF FIXED CRANES.

Two kinds of Crane Bases—Two Classes of Fixed Foundations—Shallow Foundations—For Derricks—For Wharf Cranes—Deep Foundations—Washer Plates—Standard Base Plate—Foundations for Ships' Cranes.

THE bases of cranes are fixed, or portable. In a fixed crane stability depends upon the foundation, in a portable crane on the relation which the wheel base, and gauge bear to the radius, and load, or to an artificial base formed by blocking girders, or to the holding power of rail clips.

When a base is fixed it is termed a foundation, when portable it is a truck, or carriage.

Fixed foundations are of a varied character. They may be divided broadly into two classes; those in which the post goes no further down than the base plate, or the ground line; and those for deep posts. Another division is that of cranes the posts of which are rigidly fixed, the superstructure alone revolving, and those in which the posts revolve, the superstructure being attached to and revolving with them. The latter is relatively a small class.

Foundations of the shallow type are shown in Fig. 81, as used for derrick cranes. A goes under the mast, and B B under the anchorages of the guys. A is subject to a downward pressure. At B B the tendency is to lift upwards or downwards, according to the position of the jib. When a load is lifted with the jib in line with a backstay, then the stay is in compression and the effect on the foundation

block is compressive. The foundations are of stone or concrete. The footstep casting of the post is bolted down on A, the tails of the sleepers are secured by the bolts which go down to the bottom of B B. The foundations are larger

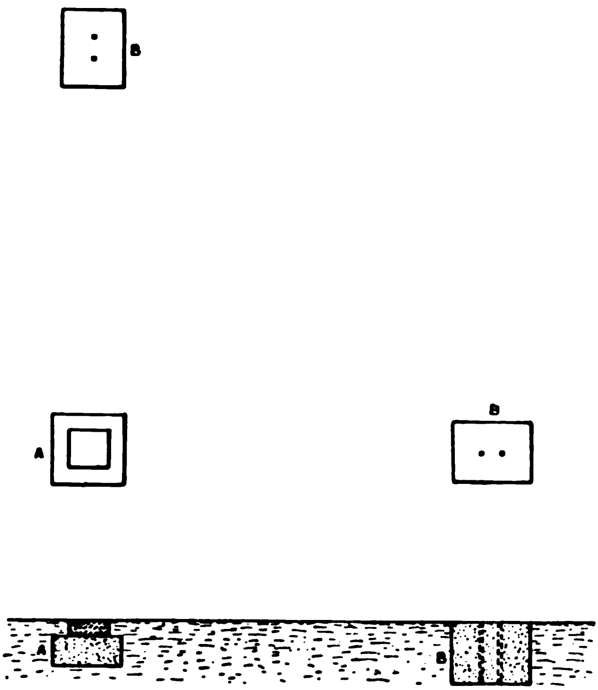


Fig. 81.

and deeper for B B than for A, being 5 ft. square and 4 ft. deep for a 5-ton crane, with a 38-ft. jib; the centres of the sleepers being 23 ft. away from the post centre.

The increase in the mass of foundations which is rendered necessary by increase in the size of cranes is illustrated

in the next figures 82 and 83, which represent respectively those for the post and guys of a 30-ton crane. The centre casting A for the post is embedded in a mass of concrete 9

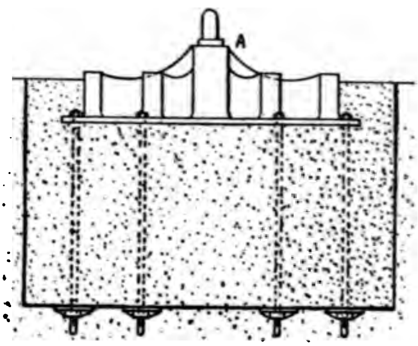


Fig. 82.

ft. square and 4 ft. 6 in. deep. The sleeper bolts, Fig. 83, pass down through a mass 9 ft. square by 8 ft. deep, in which the precaution is also taken of sloping the faces inwards in

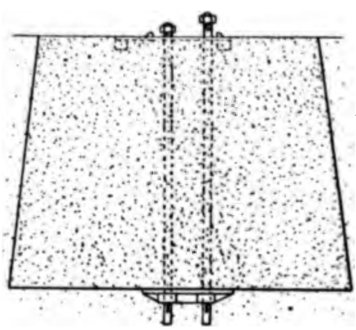


Fig. 83.

dovetail fashion. The bolts in each case pass down through the concrete to the bottom, through broad washer plates. The centre casting in Fig. 82 not only carries the mast

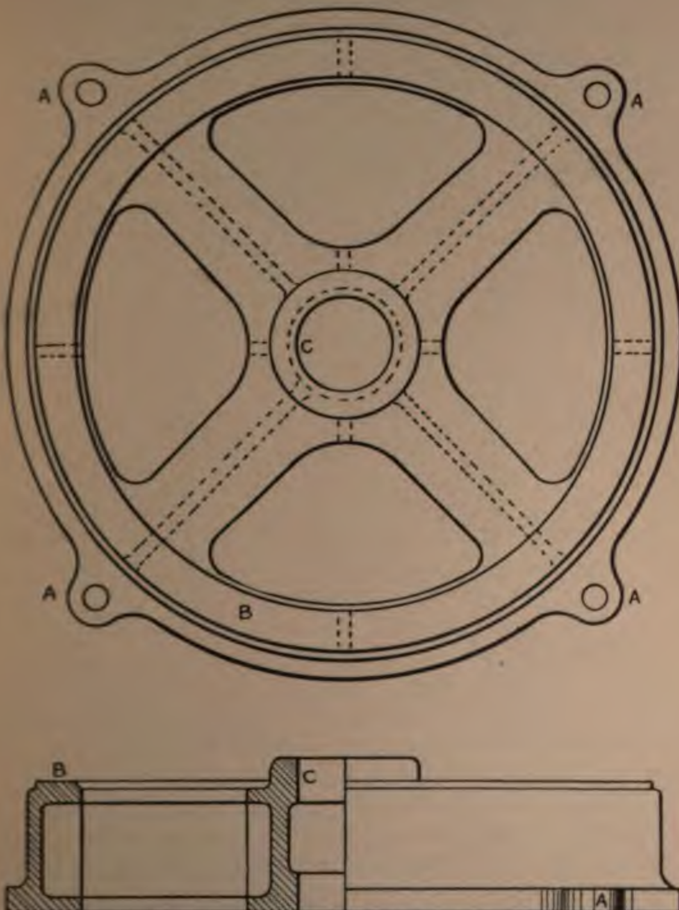


Fig. 84.

pivot, but also the slewing or curb ring, the latter being bolted down on the top faces of the half-dozen bosses distributed round the circumference of the plate.

A common type of surface foundation used for wharf cranes in which the post is fixed, and the superstructure slews, is shown in Fig. 84. It is a circular casting laid upon concrete, or masonry, or heavy timber, and bolted down with four long bolts passing through the lugs A A A A. The face B receives the curb ring, and the centre hole C the post. The stress on such a casting is constantly changing

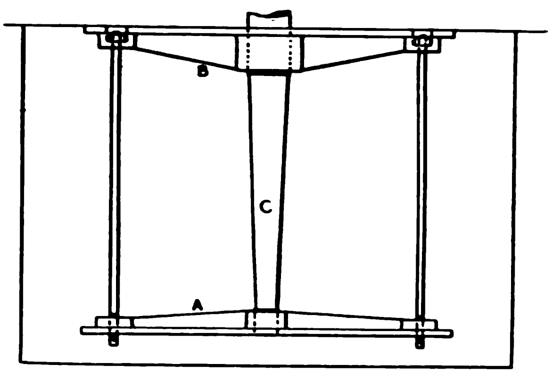


Fig. 85.

as the superstructure rotates, the side next the load being compressed, and that opposite tending to lift. The bolts are calculated for tension, but the casting is designed to withstand mixed stresses, for which experience is the only safe guide. When such castings fail they generally rupture at or near the central boss, due to the leverage of the load at the post head. It is highly essential that the bedding of the base on its foundation is perfect everywhere.

The usual pattern of deep foundations is that in which two broad plates,—the base plate, and foundation plate—are united with long bolts going down through concrete, Fig. 85.

The foundation plate A is buried deeply in this, and the base plate B lies level with the ground. Great depth is necessary to afford the required stability. The crane post C is carried down and stepped into the bottom plate. The stresses on the foundation plate are very severe, and the central boss is made correspondingly strong, as are also the plated portions, and these too are stiffened with deep ribs. The bolts are calculated for tension, and therefore work out of large diameter.

The foundation plate is often omitted, and washer plates substituted, similar to those in Figs. 82 and 83. A washer plate is shown in Fig. 86 with its bolt head. The neck of

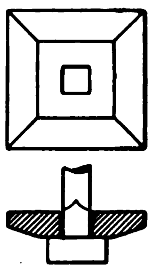


Fig. 86.

the bolt is made square to prevent it from rotating during the tightening of the nuts at the top. When foundation plates are used, cottared ends are often substituted for square necks on the bolts—an example of which is seen in Fig. 85.

A standard type of base plate for light cranes and those of moderate power is shown in Fig. 87, in plan, and cross section, with the curb ring bolted upon it, and with a portion of the post. The recesses for the nuts of the long bolts which are tightened with a box spanner are seen at the corners, compare with Fig. 85. The broad solid plate is well ribbed, which with its concrete bedding renders it very strong.

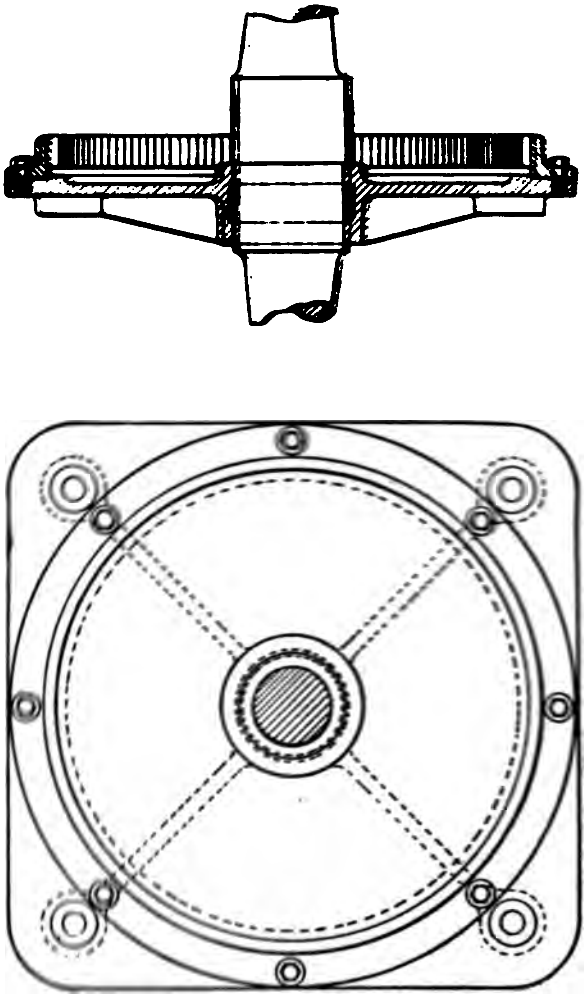


Fig. 87.

Cases arise in which neither concrete nor stone foundations can be made use of. Cranes put on ship board, and the floating cranes, are illustrations in point. Then the foundation goes down to the keel plates, or to lower decks, and vertical plates and diagonal bracings afford support

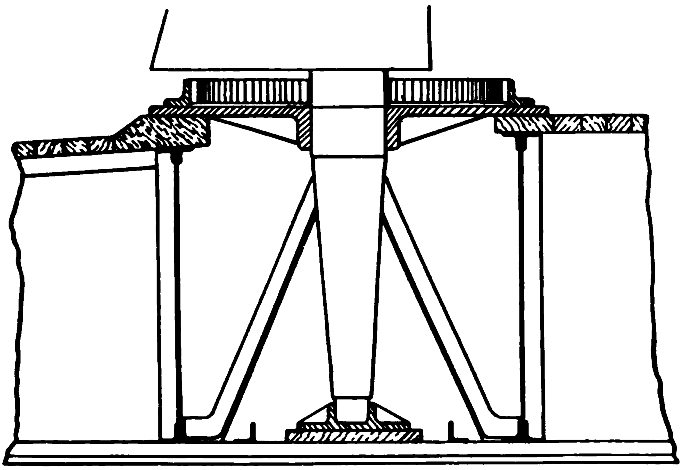


Fig. 88.

immediately beneath the base plate, as shown in Fig. 88. In ships' cranes the loads of which do not exceed 2 or 3 tons, it suffices to bolt the base plate on the upper deck, and the footstep for the post on the deck beneath, without using any bracing.

CHAPTER VII.

THE BASES OF PORTABLE CRANES.

Stability of Trucks—Angle of Upset—Methods of Construction—Trucks of Cast Iron—Plated Trucks—The Centre Castings—Completely Fitted Trucks—Cross-over Wheels—The Travelling Wheels—Wheels of Cast Iron—Chilled Wheels—Steel Tyred Wheels—Wheels for Double Rails—Stresses on Wheels—The Bearings of Trucks and Axles—Axle Bearings—Toothed Gearing—Blocking Girders—Rail Clips.

THE trucks, which are the bases of the portable cranes, are subject to much variation in design. But any crane is, or should be, calculated to lift its maximum load at maximum radius when the jib is in a longitudinal position,—that is, in line with the wheel base of the truck. Few cranes except those of very short radius, or of specially wide gauge, will lift similarly across the gauge, or at right angles with the first-named position. Between these two extremes there is an angle at which the stability of the crane becomes insecure —the angle of upset—with which the crane driver should be familiar, in order to know how far round he may safely lift without having recourse to artificial aids to stability, as rail clips, and blocking girders. Of late years the excessive use, or rather abuse, and the too frequent necessity for recourse to these fittings has been objected to, and as a result cranes are now demanded and supplied of more stable character, so that except in those of long radius, the lift in numerous cases can take place in any position, without resorting to the use of girders, or rail clips.

The construction of trucks is varied in the following ways. Some few are made of timber framing, with a centre piece

of cast iron into which the post is stepped. In many standard cranes of low and moderate power, cast iron is used wholly for the framing, including its centre boss, roller path, and axle bearings. But in the best cranes of moderate,—and in all those of high capacity,—the framing is steel-

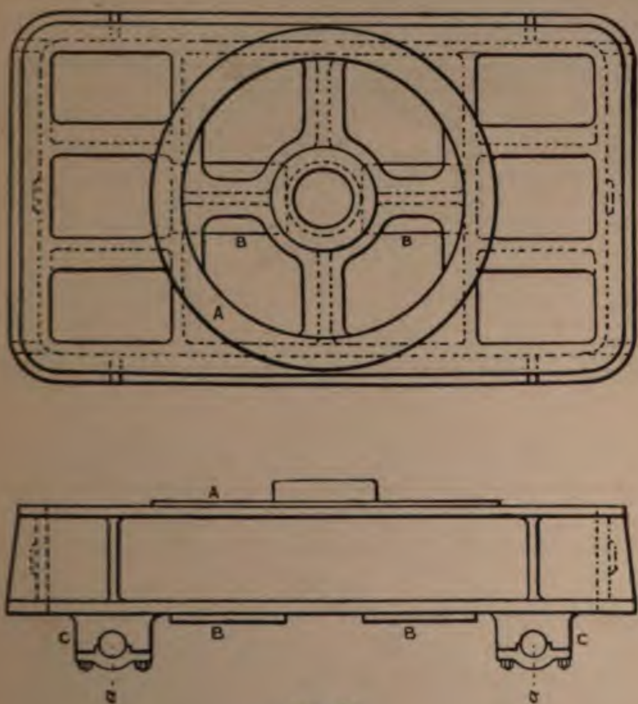


Fig. 89.

plated with the centre only of cast iron, and the axle bearings are cast, and bolted on. Many trucks are made to permanent way requirements, with axle boxes, springs, buffers, &c. Many are made with two sets of wheels,—one within the other,—to adapt the crane to two different gauges. Some

are constructed with two sets of wheels at right angles, for cross travelling.

A standard truck made wholly of cast iron, and suitable for cranes of standard gauge,—namely 4 ft. $8\frac{1}{2}$ in., and up to about 5 tons capacity,—is shown in Fig. 89. The bed is in effect a girder, supported on the axles at the centres, *a a*,—the overhanging ends being of no account. The

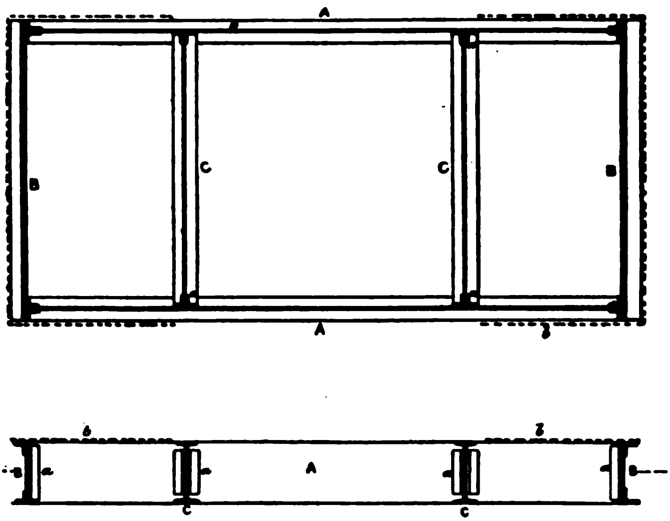


Fig. 90.

bottom flange is in tension, the top one in compression, which explains the greater width and thickness given to the bottom flange over the top one. A is the facing on which the curb ring is bolted, B B are facings on which brackets are bolted to carry the shafts for the travelling gears. The bearings C C are cast with the bed, and fitted with cast-iron caps. Brackets above the bearings afford support to them. The brackets at the ends are fitted to support the bottom flanges there when blocking girders are in use.

Fig. 90 is an illustration of a built-up truck as it leaves

the plating shop in readiness to receive its cast-iron fittings. It is typical of forms of the same general design, in which details are modified. In the figure A A are rolled joists of I section. But in heavy cranes, though the same section

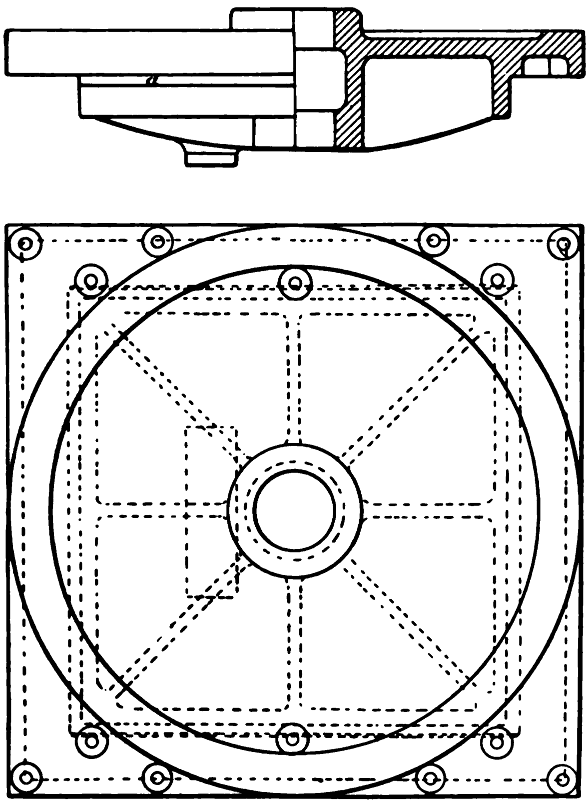


Fig. 91.

would be retained, the sides would be built up with plate and angles, as being a form that corresponds more closely with the nature of the stresses imposed, as may be seen in diagrams of moments of inertia for the I section. A bed of

this kind is seen in Fig. 93, p. 85. Sometimes the section is that of a channel, either rolled, or built up, just as the ends B B are in Fig. 90. Rolled sections C C (or built-up ones) connect the sides A A, with angles *a a*, away from the ends, and in positions which are determined by the centre casting. Such a frame would in itself be subject to cross working, and require bracing, but for the fact that the centre casting

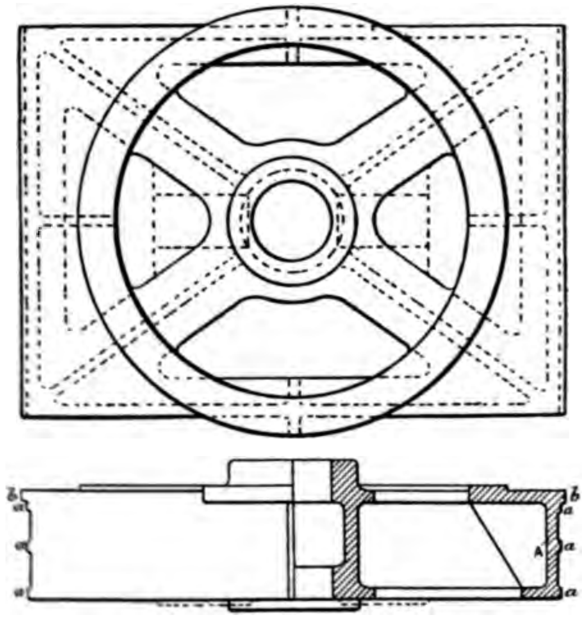


Fig. 92.

renders it very rigid. This casting fits upon the top flange, and between the sides A A, and cross girders C C,—see Fig. 93. The dotted outlines indicated at *b b* simply denote cover plates, covering those openings which are not occupied by the centre casting. The whole of this framing is secured by rivets.

Two typical forms of centre castings are shown in Figs.

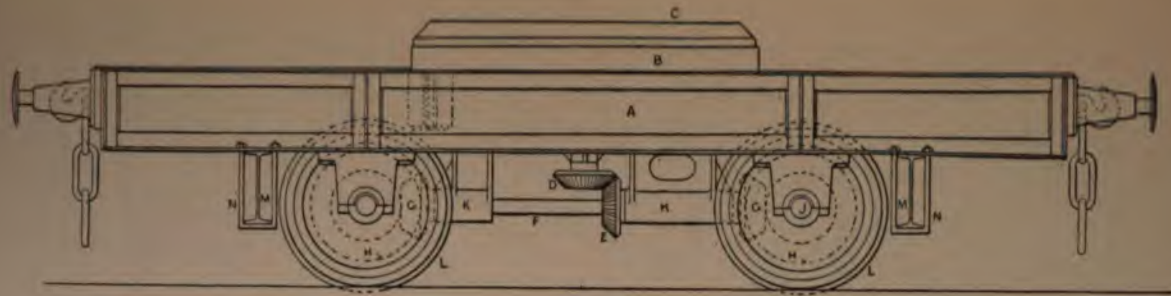


Fig. 93.

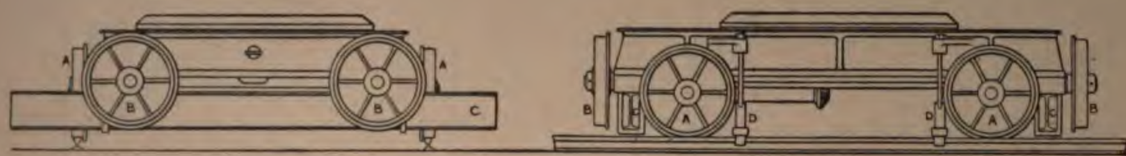


Fig. 94.

91 and 92. That in Fig. 91 is designed for bolting on a truck like that illustrated in Fig. 90,—its relation to the plated work being seen in Fig. 93. It is secured with bolts passing down through the holes seen in the plan view, and security depends mainly on these bolts, though a fillet *a* against each edge fits closely to the inner edges of the side girders. But the centre in Fig. 92 fits by the strips *a a a* down the entire depth of the girders, which in this case are of ⊏ section, and the top flange is reduced to a mere fillet *b*, the edge of which fits on the top edge of the ⊏ section. The frame is secured to the plated work with bolts passing through its sides A. Both castings carry facings for the curb ring, the centre boss for the post, and a facing or facings for the travelling gears. It is usual to make the bottom flanges in Fig. 92 thicker than those in the top, but it is not necessary in a casting so well ribbed. The parabolic outlines of the ribs in Fig. 91 are a substitute for bottom flanges, giving a deep section where the stress is greatest.

Fig. 93 is an external view of a truck A, built up with plate and angle, and fitted with its bed B, travelling gear, blocking girders, &c. The centre bed is of the type shown in Fig. 91. The curb ring C is bolted upon it, of a section shown in Figs. 142 or 143, p. 142.

The bevel gears transmit the travelling motion derived from the upper portion of the crane, through the hollow post, see Fig. 21, p. 20. A shaft that comes down the post has the mitre wheel D upon its lower end. This drives E and the shaft F, on which are the pinions G G, each driving its wheel H, situated to right and left of the shaft F, and each keyed on its axle J. The shaft F is carried in the bearings K K, bolted to facing pieces on the bottom of the centre casting. On the axles J the tyred wheels L L are keyed. M M are blocking girders, supported in the stirrups N N. Buffers, draw-hooks, and chains complete the truck. The blocking girders and rail clips are treated at greater length at pp. 93 and 94. In the meantime a truck of another type is illustrated.

Fig. 94 is a cast-iron truck fitted with two sets of wheels; —the regular set A, and a special cross-over set B, used when the crane has to be transported to another set of rails which are not connected with turntables. The cross rails are laid temporarily in place over the others, the crane being jacked up, or lowered. In heavy Goliaths which are sometimes fitted in this way, the wheels alone are raised or lowered by screwjacks fitted to the bearings. In this example, blocking girders C C are fitted, and also rail clips D D, for an account of which see pp. 93 and 94.

The travelling wheels of trucks are variously made. They

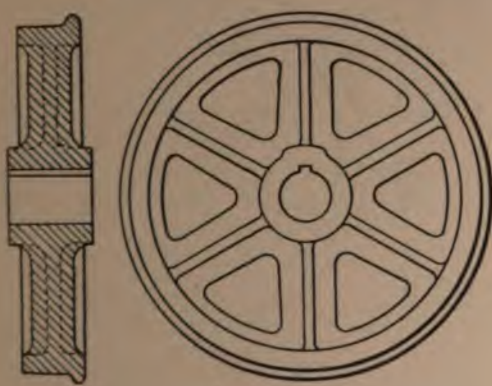


Fig. 95.

are of cast iron or steel, with arms, or solid plates. They are of wrought iron, built up like railway wagon wheels, and are made with cast iron, or steel centres, steel tyred. Cast-iron wheels are only used for the cheap cranes of low power.

Fig. 95 illustrates a cast-iron wheel suitably proportioned, but it is not a type to be recommended for any cranes of over a ton, or 30 cwt. power. The reason is that the arms are very liable to fracture, either next the boss, or next the rim, under the shocks of severe duty. They are better

if made in steel, but steel is subject to severe shrinkage strains which are a source of weakness.

The proper form of cast-iron wheel is that with the solid plated centre, Fig. 96, in which the ribs may or may not be retained. They help to support the rim, and if omitted the web should be thickened.

The treads of these wheels are subject to rapid wear, which is not equal all over, but produces deep grooves. This results in irregular running, and ultimately in fracture. If the rims are made thicker to leave allowance for re-turning,

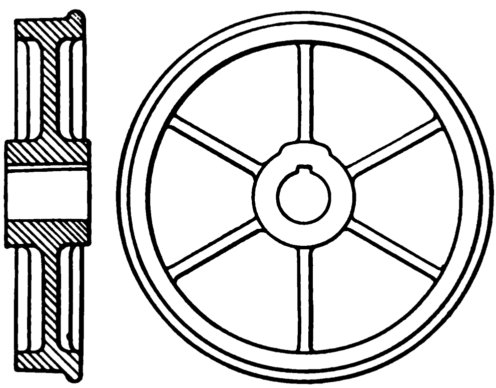


Fig. 96.

then they become too thick to permit of regular and equable shrinkage, and this is liable to set up internal tension that may produce fracture in service.

A device formerly employed to a greater extent than it is now, was to chill the treads, in order to delay the grooving action of the rails. Figs. 97 and 98 are illustrations of such wheels. In the first the chilling is deep, hence the rim is made thick to afford a good backing of soft metal, and the web is made thick also to ensure equal cooling. But such wheels are never trustworthy, being liable to fracture,—parting in halves due to the extra shrinkage and tension round

the rim set up by chilling. The wheels in Fig. 98 are little better, though in theory the dishing of the web should offer little or no resistance to the shrinkage of the rim. When

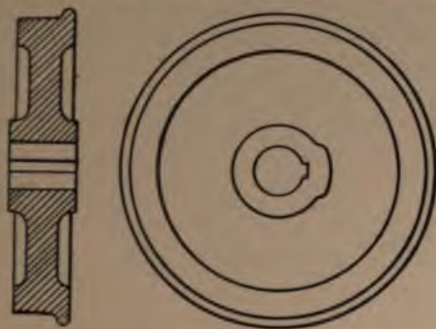


Fig. 97.

these fracture they fail by the web or the boss breaking clean away with a circular fracture. Properly such wheels should have double webs, with cored spaces between, but the number required of them does not warrant the expense

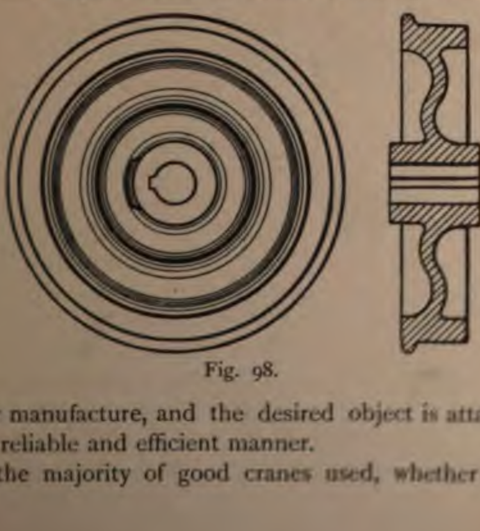


Fig. 98.

of their manufacture, and the desired object is attained in a more reliable and efficient manner.

For the majority of good cranes used, whether of low

power or high, the steel tyred centres, Fig. 99, are used. They are strong, safe, and very durable,—conditions which

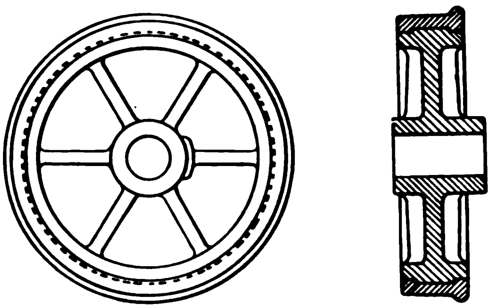


Fig. 99.

are highly essential in heavy trucks. The tyres used are of Bessemer steel. The centres are of cast iron, or of cast steel, and the tyres are shrunk on, usually without further aid from tyre bolts,—the tightening of the tyre due to shrinkage as it cools around the centre, and the shallow check, being sufficient to retain it in place.

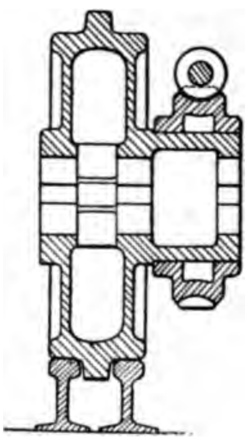


Fig. 100.

Wrought-iron built-up wheels are now only used when the cranes are required for permanent way, with spring axle boxes.

In the illustrations shown, the wheels are designed for running on single rails only, and these are employed in cranes as large as 30 to 50 tons capacity. At, and beyond these powers, double lines of rails are usually required, and then the wheels are made with the flange central, to run between the rails as in Fig. 100. They are cored out hollow as shown, or sometimes plated and ribbed.

The particular example shown is taken from a German crane, in which the ground wheels are driven by a worm, and worm wheel.

The stresses on wheels are calculated for simple crushing of the material. The total moment of the crane, loaded at maximum radius, is reckoned as coming on the total cross section of the number of wheels upon which it may be concentrated, in the worst possible position. This may be one only in a rotating crane, two in a Goliath or crab.

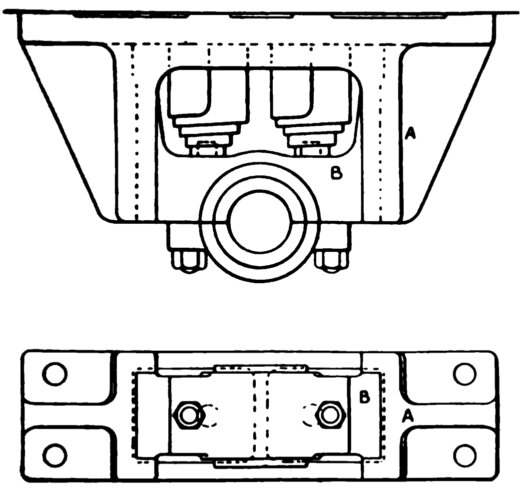


Fig. 101.

The bearings in these trucks are differently made, according to circumstances. For ordinary service about yards and factories they are simply divided,—of the plummer block type,—as in Figs. 89 and 93, pp. 81 and 85, and used with or without brasses. The thrust of the axles is always upward, and therefore when brasses are used it is a frequent practice to insert one half brass only in the top, making the cap wholly of iron. The cap is really nothing more than a keep, and

it need not even be shouldered into the block. Many cheap cranes are not even fitted with caps, but plain dead eye bearings, as in Fig. 102, are used. In cranes used on permanent way, axle bearings in horn blocks, and with springs, are fitted. Many heavy cranes for yard and factory service are also fitted thus. The springs relieve the truck from severe stresses due to shocks on uneven tracks, and should be employed therefore in high-class cranes of great power, and subject to severe duty.

A special form of bearing used for Titans, and heavy Goliath cranes, is shown in Fig. 101. The main body of the bearing A is bolted to the sills of the bottom girders. The bearing proper B is fitted within this by vertical guiding edges, seen in the plan view below, and the upward reaction of the axles is resisted by the volute springs which fit in recesses cored in A.

The area of axle bearings is calculated on a minimum pressure per square inch, which varies with manufacturers' ideas, but the allowance is usually higher than that for rolling stock. The stress on axles is calculated by the method explained in Chapter VIII., p. 103.

There is a considerable amount of toothed gearing attached to the trucks for the operations of the travelling wheels. The amount of these fittings varies in cranes of different sizes and types. The gearing is generally worked from the same engines on the side frames, which lift the

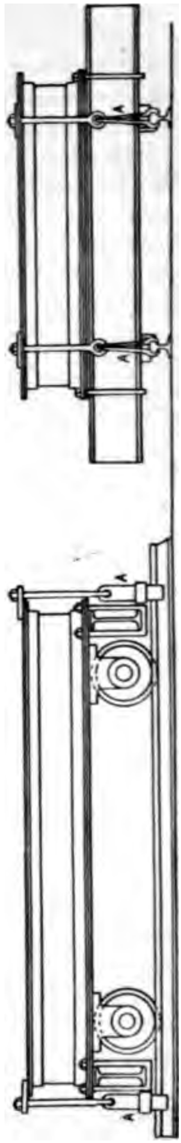


Fig. 102.

loads, slew, &c. But occasionally engines are attached to the truck for the special purpose of travelling. This is only done in the case of cranes of high power, say from 10 to 15 tons, and upwards. The general questions relating to gearing will be found treated in Chapter X., p. 130.

Of vital moment in the stability of most portable cranes is the artificial assistance derived from blocking girders, or from rail clips. Blocking girders, M, Fig. 93, p. 85, C, Fig. 94,

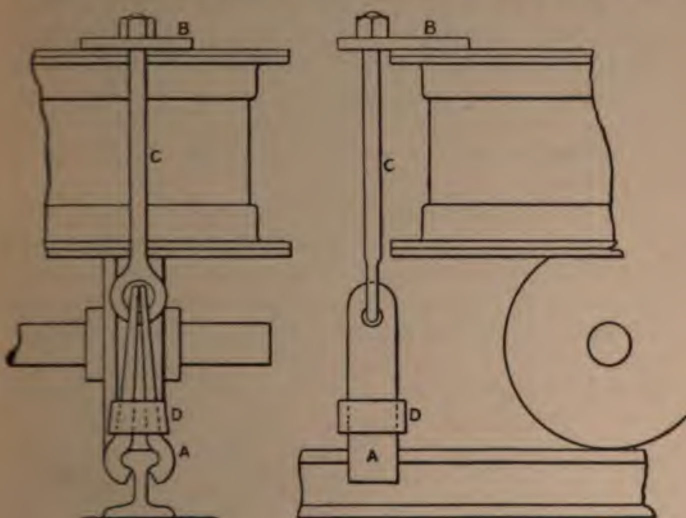


Fig. 103.

p. 85, increase the base of the crane. Rail clips, seen at A in Figs. 102, 103, and at D, Fig. 94, p. 85, bind the truck fast to the rails, and so prevent it from upsetting when the angle of upset is passed. These devices are variously modified, but the essential elements are present in these figures.

The blocking girders are in their simplest form rolled joists of I section, of a sufficient length to ensure the stability

of the crane when lifting maximum loads across the t
They are supported loosely in straps as shown, ar
these figures they are in a single length, so that they a
stand out on each side. When this is objectionable,
are made of telescopic form, to slide in and out, or the
hinged, to lay close to the truck when not in service.
stead of girders, broad blocks operated with vertical scre
sliding bearings standing out from the sides of the truc
sometimes fitted, the blocks being lowered to rest or
ground when required. Timber packing is laid be
the ends of the girders which are shown in the fig
Sometimes customers will have both rail clips and blo
girders fitted to cranes, as in Fig. 102, to be able to
either at discretion, or that which happens to be
convenient.

The usual form of rail clips is shown in Fig. 103.
pair of clips A is suspended from a plate B bolted or
truck by the screwed loop C. When not in service the
elevated by the screw. When required they are dro
into place, and secured by letting the loose clip D drop
them.

CHAPTER VIII.

THE FRAMES OF TRAVELLING CRANES.

Definitions of Travelling Cranes—Variations in—Materials—The Place of Timber—Its Disadvantages—Trussed Beams—Details of same—Stresses in Simple and Compound Trusses—Stresses on End Cradles—Wheel Base—Stresses in Wheels and Axles—Traveller Frames—The Place of Rolled Joists—Built-up Girders—Sections of Beams—The Importance of Reduction of Weight—Rigidity—The Bridge Type of Girders—Various Fittings of Wheels and their Bearings—Relative Positions of Main Girders and End Cradles—Goliath and Gantry Framings—Definitions—Timber-framed Goliath—Steel-framed ditto—Framing of Gantry Crane.

UNDER travelling cranes we include all those which come under the class of Overhead travellers, of Goliaths, and gantries. The term is applied exclusively to these, notwithstanding that the portable cranes with trucks travel on rails. But the term portable,—or the term locomotive, also applied to these,—distinguishes them from the travelling cranes. The distinction is purely conventional, but is always understood.

In so large a number of designs as those which exist in the frames of travelling cranes we naturally find a great deal of variation in the forms of the frames. These are too numerous to be adequately dealt with in an elementary work. The treatment of stress problems alone, apart from the mechanical details, would occupy a volume. Those who desire to study them may consult any standard work on statical problems. In the drawing office the moment of inertia of sections is calculated, or more often is taken from books of reference. The questions of span and of trussing

are determined by calculations, excepting sometimes in girders made of plain rolled sections for which the section books of manufacturers are consulted. It must also be borne in mind that when firms are always constructing travellers, standards are evolved by which the labour of calculation is rendered unnecessary for any cranes identical in span, and conditions of loading. Bearing these several facts in mind, our remarks may be condensed on practical matters.

Practically but two materials are employed for the frames of travellers,—timber, and steel. For many years wrought iron was employed, but it is now largely displaced. With regard to the merits of the two materials, though some very large traveller girders have been constructed of timber—up to 45 tons, within the writer's experience,—yet it is not held in so much favour as formerly. The reasons are these:—That large balks of timber are not very readily obtained in a perfect condition of soundness, straightness of grain, and freedom from knots. That since steel came into general use, the choice between steel and timber is greatly to the advantage of steel, by comparison with that of the choice between iron and timber. Iron was never rolled in such massive sections as steel is, and therefore iron girders were built up in a larger number of pieces than steel, costing more for labour. And there are many travelling cranes for which rolled steel joists are obtainable of dimensions sufficiently large,—rendering unnecessary any cost for building up.

But timber is of value, and is preferred in the following cases:—When a firm of builders purchases one of the sets of ironwork which are supplied by many crane firms, and constructs their own timber framings. When the cost of shipment abroad of heavy steel girders would be prohibitive, the ironwork for the crab and travelling gears is shipped, and the timber work constructed on the spot. This is the best plan to adopt in Tasmania, Vancouver,

Fig. 104.

and some other districts where large timber trees grow. But it cannot be adopted in tropical countries where ants and other insects commit great ravages in timber. Generally when this material is selected it is on the ground of economy, because it costs less than steel. In the smaller travellers, however, this difference need not be great.

Disadvantages in using timber are, that it is subject to decay, delay in which is mainly a question of proper care and protection, and that in the case of overhead travellers the beams have to be trussed. Steel girders are, with few exceptions, self-sustaining.

Fig. 104 illustrates the timber-trussed framework for an overhead travelling crane. It must be borne in mind in this and other illustrations to follow that there are many details in design, though but one example can be shown. For instance, though here both the main beams and the end beams are of timber, it is as frequently the practice to attach cast-iron end beams, or "cradles," to timber, so making a composite framing.

Though this structure has a simple appearance, there are a number of matters to be considered in the design. First of all, there is the span A, or distance from centre to centre of the running wheels, which is governed by the width of the gantry, which again usually de-

pends on the width of the shop. This in turn determines the length of the wheel base D, Fig. 105, which must be sufficiently long,—usually in the proportion of about 1 to 5, or 1 to 6 of the span,—to prevent risk of cross working of the traveller on the rails. On the span depends the proportion which the depth of the main beam B, Fig. 104, bears to its length and section. This, however, while absolutely

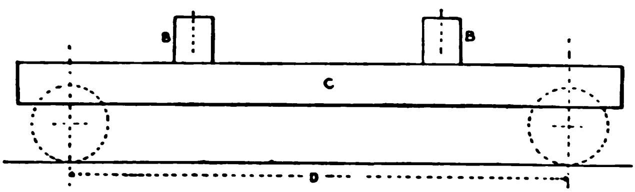


Fig. 105.

correct in steel beams, is only approximately so in timber beams, because in these the stresses must be translated through truss rods;—timber of reasonable depth alone being insufficient. The method of trussing, moreover, affects the result. A truss may be simple, see Fig. 106, or compound as in Figs. 104, 107, 108. Then the weight of the

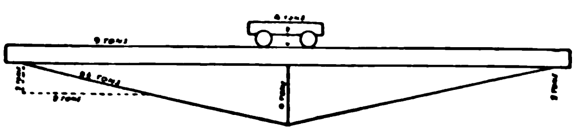


Fig. 106.

girders themselves, and of the crab and its load, and its position, has to be considered. The length also of the wheel base D affects the stresses on the end cradles C, in Fig. 105.

Looking at Figs. 104, 105, we see that two timber beams B B, of square section, are carried on end beams C C of timber, and the latter on flanged wheels. Properly, of course, a girder section should measure considerably more

in depth than in width, to correspond with the stresses, and this rule is universal when steel girders are employed. But in timber it is more convenient to use square balks sufficiently wide to ensure stiffness in the lateral direction, and to provide for the necessary strength depthwise by trussing.

Cast-iron connections are necessary for the truss rods. These comprise two struts E E, in the double or compound truss, by which the rods are carried down to the proper

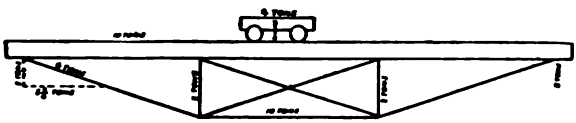


Fig. 107.

depth, and anchorages F F at the ends, which are fitted over the timbers, and against which the tension of the rods is adjusted with nuts. In the compound truss, iron plates G G are required to receive pins that pass through the timber beams, and secure the bracing rods thereto. In many cheap cranes the struts E E are made of timber. Another variation is the use of flat bars instead of round rods for the truss members.

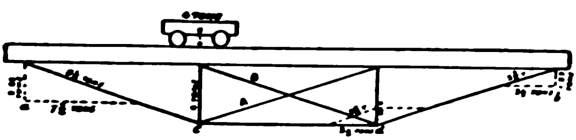


Fig. 108.

It is usual to estimate the strength of a trussed beam when the load is at the centre, which is the position of greatest stress. In a compound truss, however, the counterbracing is not stressed when the beam is centrally loaded, so that it is necessary to estimate the effect of the load when the counterbracing is loaded at its maximum, which occurs when the load is over one strut.

In a simple truss the stress is reckoned as in Fig. 106. By the parallelogram of forces we see that a total load of say 4 tons imposed on the centre would produce a reaction of 2 tons on each end support. Measuring down 2 tons on a scale, drawing a horizontal to meet the truss rod, and measuring the diagonal, we have $9\frac{1}{2}$ tons tensile stress on the truss rods. There is also 9 tons compression on the beam. Breaking loads with ample margins of safety are deduced from these.

Taking the compound truss in Fig. 107 and loading it with 4 tons centrally, the tension on the main diagonal rods is found to be 6 tons. The compression on the beam will not be as in the previous case. To obtain it, multiply the reaction at one end by half the span, and divide by the depth of the truss. Say the span is 40 ft., and the truss depth 4 ft. in the middle, then the compression on beam and bottom tie rod is—

$$\frac{2 \text{ tons} \times 20 \text{ ft.}}{4 \text{ ft.}} = 10 \text{ tons.}$$

The compression on the struts is ascertained by dividing the load on the beam by the number of struts. Thus—

$$\frac{4 \text{ tons}}{2 \text{ struts}} = 2 \text{ tons.}$$

When a beam is loaded away from the centre, the reaction on the supports will be in inverse proportion to their distance from the load, or in other words the end supports will be loaded the more as the load approaches more nearly over them. Thus if the load of 4 tons is in the position shown in Fig. 108, at one-third of the span away from one end, the load on *a* will be 2.66 tons and that on *b* 1.33 tons. But the loading shown alters the strains in the tension rods, as is seen by the diagrams in Fig. 108. The counterbracing rods A and B are alternately in tension as the load moves away from one end to the other of the traveller beams. The maximum intensity of the stresses

occurs when the load is directly over a strut, as shown in Fig. 108, when A is the member in tension.

To obtain the various stresses, the reaction at the end *a*, due to the full load of 4 tons at *c* is set off from a scale = 2.66 tons, and a horizontal drawn. The stress on the diagonal at that end is found to be $8\frac{1}{4}$ tons. At the other end the stress on the fellow rod is reduced to $3\frac{3}{4}$ tons. The stress on the diagonal A for the position shown is obtained by marking the compression on the further strut d = that on the end support b next it,—namely, 1.33 tons. Draw a line from its termination parallel with the counterbrace A. Its length then equals the stress on A, namely $3\frac{3}{4}$ tons. The horizontal line gives the stress on the horizontal tension bar = $3\frac{1}{2}$ tons.

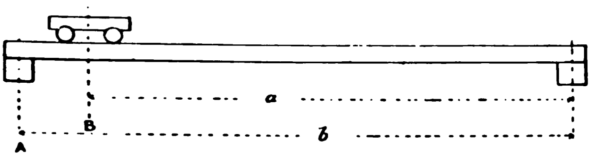


Fig. 109.

The stress on the end cradles, Fig. 105, is calculated as that for a beam supported near the ends, over the wheel centres, or wheel base D, and loaded at the points where the main beams B B come on. The load of the beams is included, and also that of the crab and its load, and is reckoned as being in the most unfavourable situation, close to the end beams near a cradle, Fig. 109.

To find the load at B in Fig. 109, multiply the total weight of the crab and the maximum weight lifted, by the distance *a*, and divide by the span *b*. If the load is 6 tons, the distance *a* 30 ft., and the span 35 ft., then—

$$\frac{6 \times 30}{35} = 5.1 \text{ tons at B.}$$

This is carried by two main girders, and therefore but

half this amount is sustained by one girder, or rather over 2½ tons. Half the weight of one main girder is added to this. Call this 1 ton,—the result is that 3½ tons are loaded on each end girder in Fig. 105. We thus have 3½ tons at B tending to bend the end cradles around the wheel axles, that is—

$$3\tfrac{1}{2} \text{ tons} \times 24 \text{ in.} = 84 \text{ in. tons.}$$

From this bending moment suitable dimensions are obtained by making use of the modulus of the section used,

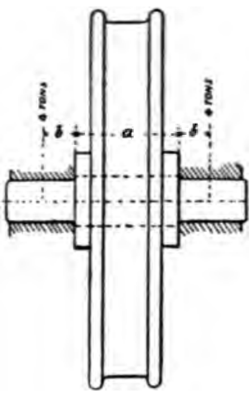


Fig. 110.

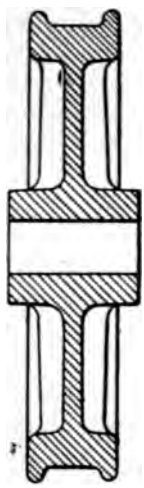


Fig. 111.

and which is applicable to all sectional forms, as described in various text-books.

The length of the wheel base is in well-designed cranes not less than one-fifth, or one-sixth of the span. Many of the older travellers were badly designed in this respect, and the wheel flanges frequently broke, due to cross working, combined with too free a fit between the flanges and rails.

The stresses on the wheels and their journals are calculated as indicated in Fig. 110. Each wheel is taken as loaded with half the total weight of the crab and its maximum load, and with half the load of the main girders, and is wholly in compression. The remarks made in reference to crane wheels, pp. 87 to 90, apply generally to those of travellers, except that the wheels of travellers are double flanged, Figs. 111, 112, to prevent risk of their running off the rails when getting crosswise. But they are made with arms, or plated, and steel tyred. Sometimes they are chilled, but it is better to use tyred wheels turned on the treads. Cast-iron wheels are sometimes ground on the treads.

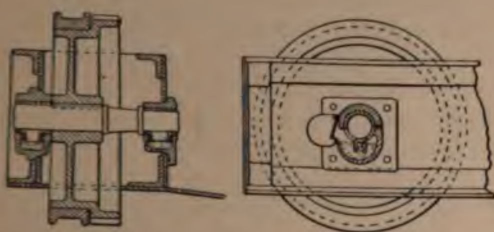


Fig. 112.

With regard to the axles, Fig. 110, these are calculated as beams of two kinds. Thus, the diameter of that portion which goes in the wheel boss is estimated as a beam having a span equal to the distance *a* between the bearings, in Fig. 110. But it is important that the boss should just occupy the space between the bearing faces in order to distribute the load over the axle. Actually the axles are made larger in the wheel boss than the calculation would give, for convenience of manufacture. The diameter of the axles is obtained by taking the load on the bearing, and considering that the axle will be subject to bending. Thus, if the bearing

were 4 in. long and subjected to a load of 4 tons, the bending moment would be—

$$4 \text{ tons} \times 2 \text{ in.} = 8 \text{ in. tons.}$$

Dividing this by 6 tons per square inch for steel, we have—

$$\tfrac{8}{6} = 1 \cdot 33$$

and from this modulus of section, the diameter of a round bar of suitable size is obtained from tables.

The stress on the wheels due to cross working of the frames sometimes causes their axles to grind hard in their bearings. This may be prevented by making the axles fast in their bearings and letting the wheels run loosely on them.

Fig. 112 illustrates the practice of Messrs Joseph Adamson & Co., of Hyde, Cheshire, in fitting the wheels of their overhead travelling cranes. The method adopted by most firms is to cast the travelling spur gear with the cast-iron wheel, or if tyred wheels are used, to key both on their shafts. Messrs Adamson cast the wheel centre in one with the toothed gear blank, and shrink the tyre on the latter, so avoiding the tendency of the wheel to work loose on its key. Also, since the load on the outer end of the axle is greater than that on the inner end, the axle is enlarged there. A self-oiling device is employed. The axle revolves in a gunmetal bush, the under side of which is cut away to be in communication with the lower part of the pedestal, forming a reservoir for the oil, which is constantly carried up against the axle by a wooden roller that floats on its surface, and is retained underneath the axle by guides cast within the chamber. A flap door gives access to the chamber.

The employment of iron and steel for traveller frames affords scope for a large variety in design and dimensions. They are suitable alike for travellers the power of which ranges from half a ton to a hundred tons or more. Iron is, however, as already remarked, little used now, having been mostly displaced by steel.

Rolled steel joists of H section are used in the lighter class of overhead cranes. They are extremely handy, because

they are ready for immediate service without any expenditure for labour, except the drilling of bolt holes at the ends, and the attachment of rails on top. The strength of these is calculated from the moment of inertia of a given section, and the span.

The simplest type of beam is that shown in Fig. 113, in which a single joist is supported on two end cradles made of cast iron, and which carry the travelling wheels. Of course such a crane carries no crab, but a jenny only. The jenny wheels may run on the top flange, or on the upper faces of

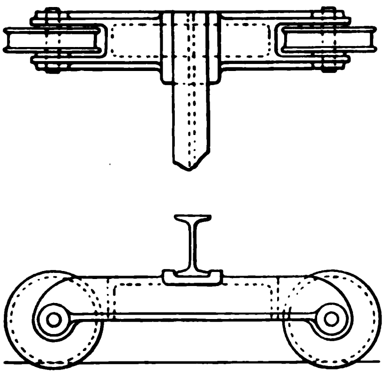


Fig. 113.

the bottom flange. Both systems divide favour, and this type of crane is in great request for loads which do not exceed from about half a ton to a ton. The jenny carries pulley blocks of numerous types, hand operated, differential, or electric.

An advance on this is the arrangement of two parallel joists bolted on two end joists of similar section, though shallower, and in which the traveller wheels are carried in bearings of various forms, Figs. 114, 115. Such a design is suitable for any travellers of moderate power, but is not recommended for the heavier types, for these reasons :—

A parallel section is not the most economical of material, and does not contain the minimum of weight for a required strength. Where a rolled joist becomes objectionable, besides its uniform weight, is in long spans where its comparatively small width gives no decent resistance to transverse loading, due to the inertia of starting and stopping a crane.

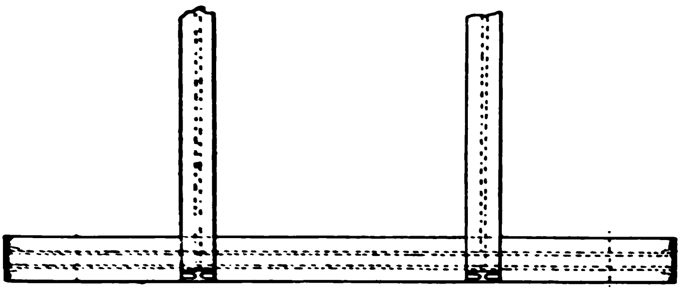


Fig. 114.

With regard to the section of a beam taken longitudinally, this should properly be composed of two parabolas, the broad ends of which would meet in the centre of the beam, for reasons which are well understood. Nearly all girders of great length, therefore, are built on this model, and usually,

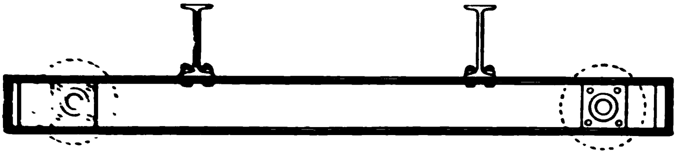


Fig. 115.

though not invariably, with the curve or camber on the lower edge. Such beams require no trussing, but parallel beams of great length would, unless made of excessive depth; or unless two beams were superimposed to form a compound girder—a wasteful disposition of material. Frequently a shallow joist is reinforced with a truss, as in timber.

In the typical fish-bellied plated girder in Fig. 116, the various members are indicated by lettering. As neither plates nor angles are rolled in the lengths required for traveller girders, these have to be built up. The web A is made in several lengths, abutting at the joints *a—a* on each side of the centre. At the centre the top and bottom flanges B are jointed at *b b*. These joints are covered with broad plates riveted across the vertical joint *a*, by the plates *c c*, and the joints *b* with the plates *d*. The angles C C jointed at D D are united with covering angles *e e*. The important point is that none of these joints are made in the same locality, but always at different planes, "breaking the joint," as the term is. At intervals vertical stiffeners E E are riveted down.

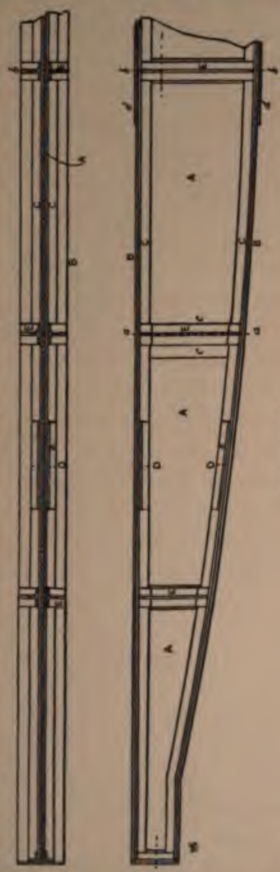


Fig. 116.

Generally a cambered beam is solid plated, and a solid plate does not contain the metal in the most economical form. During recent years, therefore, crane-makers have borrowed ideas largely from the bridge-builder, and constructed beams of parallel and cambered form with lattice bracing, so saving metal over the plated design, while disposing struts and ties approximately in the directions in which the stresses are transmitted. The

result is a lightening of girders without diminution of strength.

With regard to the section of a beam taken in the vertical direction, a study of the problems involved in the moment of inertia of a section shows that the maximum stresses occur on the top and bottom of a symmetrical beam, and diminish to nothing at the neutral axis. From this the deduction is obvious, that flanges should not be of uniform thickness, and that webs should not be heavy at, and near the centre. These conditions are approximately fulfilled in rolled joists, and may be more closely approximated to in girders which are built up with webs and angles, or with angles and tees and bracing, because the metal can be massed where wanted most, and diminished about the central parts.

In case it might be supposed that overmuch attention has been given to the correlation of material to stresses, it is well to point out that the question is less one of cost, than of weight. It costs more to build up girders than to use rolled joists. It would generally cost more than the value of the metal saved. But that is hardly the point at issue. The dominating fact is, the reduction in the dead weight of the travelling crane. By lessening this, the stresses on the travelling wheels and axles are lessened, and less power is required for operating, a point of much importance in the high-speed travellers which are now so common.

But the designing of girders is not quite so simple a matter as this. Two other points have to be settled, —rigidity depthwise, that is, as opposed to buckling or crumpling, and rigidity sideways, to resist the lateral stresses which are produced by the rapid longitudinal movement of the crane.

Rigidity depthwise is imparted by the vertical stiffeners, usually of tee section, which are riveted down the webs at intervals. Rigidity sideways is imparted in two ways. In one the top and bottom flanges are widened. In the

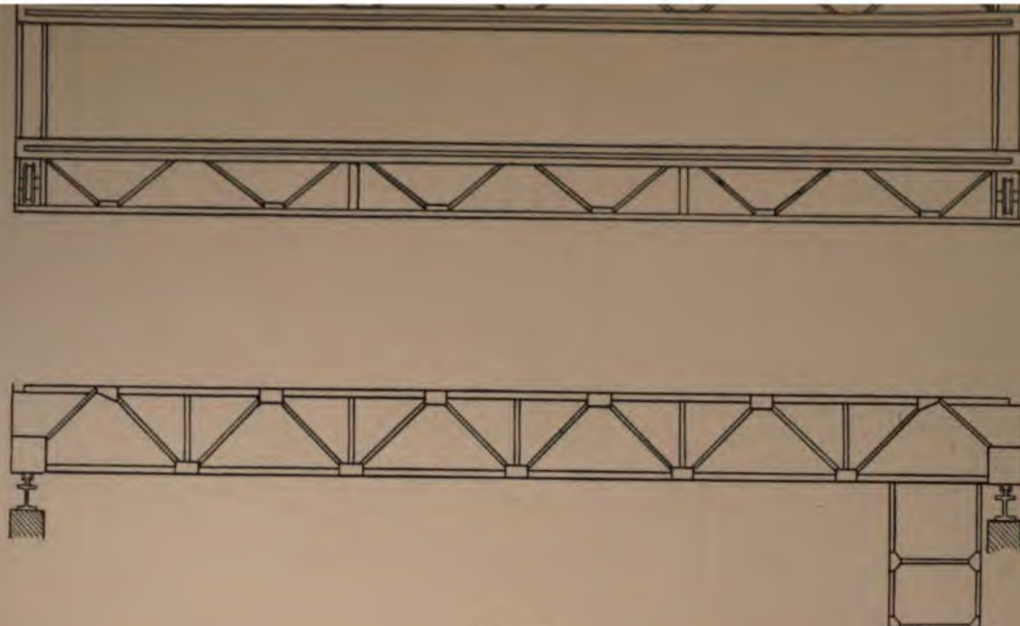


Fig. 117.

[redacted]

heaviest cranes the box girder is used, which is practically two girder webs placed at a few inches asunder, and riveted thus with top and bottom flanges.

In the bridge type of girder built with bracings, a practice which has been growing recently is to attach lateral bracing to the outsides of the main girders, Figs. 117-119. This also serves as a platform. It combines great lateral rigidity with lightness, and is a suitable design for the modern high-speed travellers.

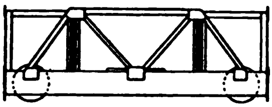


Fig. 118.

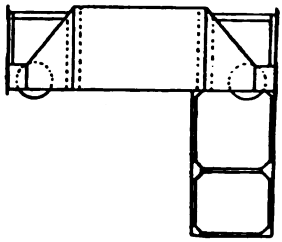


Fig. 119.

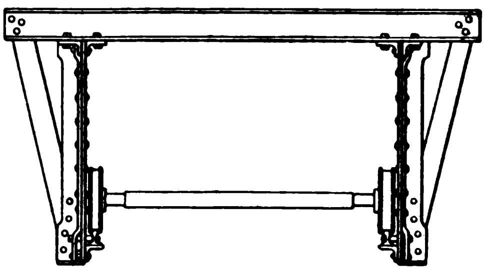


Fig. 120.

A special type of girder is that of Messrs William Sellers & Co., of Philadelphia, in which the crab runs between the sides, Fig. 120, instead of on the top of the beams. This is done mainly with a view of keeping the centre of gravity low down.

The end beams or cradles and their axle bearings are also subject to much variation in design. These frequently consist of rolled joists, Fig. 121, in others they are formed of two channels placed back to back with an interval between, in others box girders are built up with plate and angle, as in Fig. 112, p. 103.

The wheels and their axles are variously fitted. The best position for the wheels is between the girders, Figs. 112, 113, 121, but they are sometimes placed on the outside. Bearings are cast solid on the girders, as in Fig. 113, but generally they are bolted on, Fig. 121. These are either of the dead eye form, or of the solid plated boss type, Fig. 115. Sometimes capped bearings are used. Bearings are brass bushed in the best cranes, though brasses need only be fitted in the top.

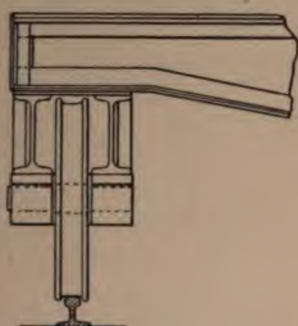


Fig. 121.

The relative positions of the main girders and the end cradles is varied according to the space available overhead. The ideal position is that in which the main girders rest upon the cradles. But very often there is not sufficient head-room to permit of this. An arrangement, perhaps equally good, and one which is preferred by some firms, is to make the main girders lay partly on the cradles, and partly abut against them, Fig. 122. This affords a good chance to make a solid joint. In another design the joint is an abutting one simply, Fig. 123, the method of fastening being through angles, or angles and gussets. In another the main girders come underneath the cradles, and are in a state of suspension. Neither of these are good joints, but they are rendered necessary sometimes

when roofs are low. In such cases the only course open is to make the fastenings of bolts or rivets secure enough to sustain the maximum stress imposed on them. Joints should be stiffened with broad gussets, and the members connected with turned bolts fitting in reamered holes.

Related to the overhead travellers are the Goliaths, and the Gantry cranes, inasmuch as they are both high above the ground, and travel on rails. But in these the crane framings descend to the ground, while the true travellers do not, but travel on gantries or runways, hence the prefix "overhead," which is applied specifically to them. It is not always easy to fix the exact meanings of the terms Goliath, and Gantry cranes. In England, Goliath always

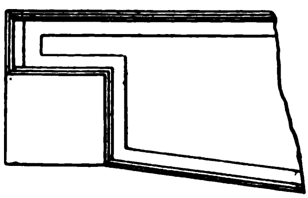


Fig. 122.

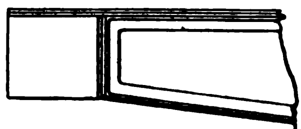


Fig. 123.

signifies a bridge type of crane which carries a crab. In America the term Gantry crane is commonly applied to this type. In England the term Gantry crane signifies a tall Goliath type of framing which carries, not a crab, but a jib crane. In Germany these are termed Portal cranes, and they are employed to a vast extent for dock and harbour work, supplanting the older wharf and hydraulic cranes.

The framings of Goliath cranes are constructed of timber or of steel. Those of Gantry cranes are seldom built of any material but steel. Timber is very serviceable for Goliath framings, especially when hand operated, and the occasions for their use are similar to those which determine the selection of timber for traveller beams, see p. 96.

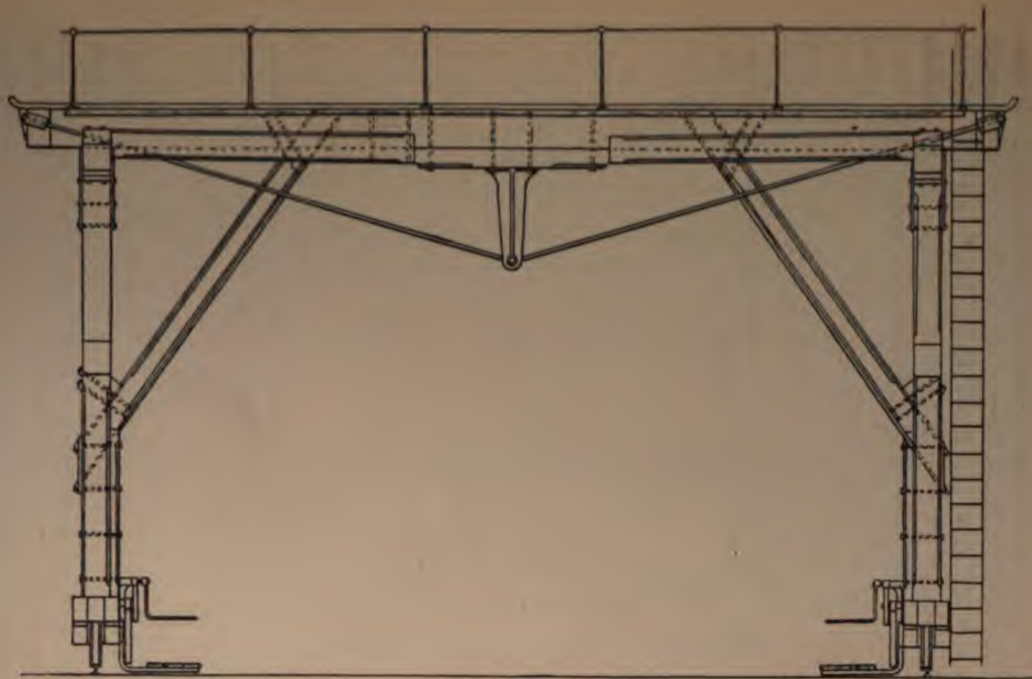


Fig. 124.

Figs. 124-126 illustrate a heavy timber-framed Goliath. The usual height of these structures is from 20 to 25 ft., while the span will range from about 20 to 40 ft. In this design we have simple trussing like that noted in connection with traveller beams, and also ample length

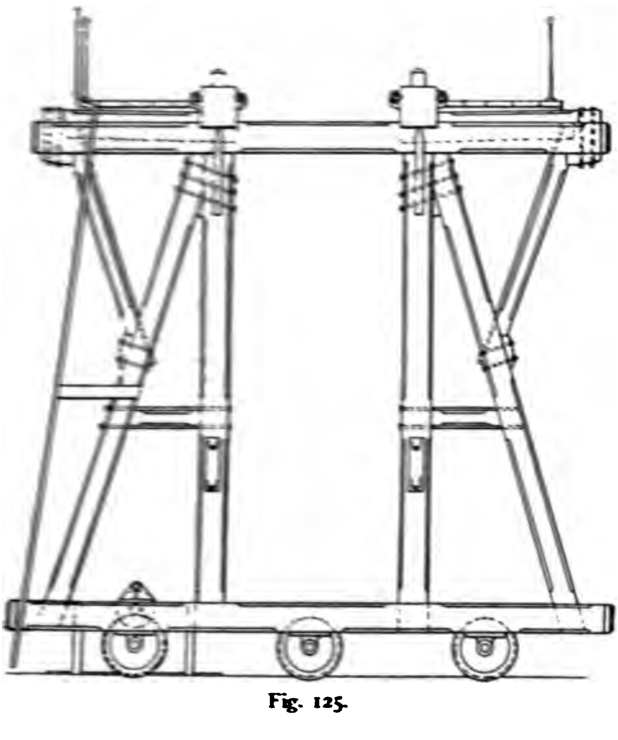


Fig. 125.

imparted to the wheel base, and double flanged running wheels. Many of the remarks made in reference to overhead travellers are clearly applicable to Goliaths, but in the latter the tendency to twisting is greater by reason of the difference due to greater height. Unless a Goliath framing is well braced it is always getting off the

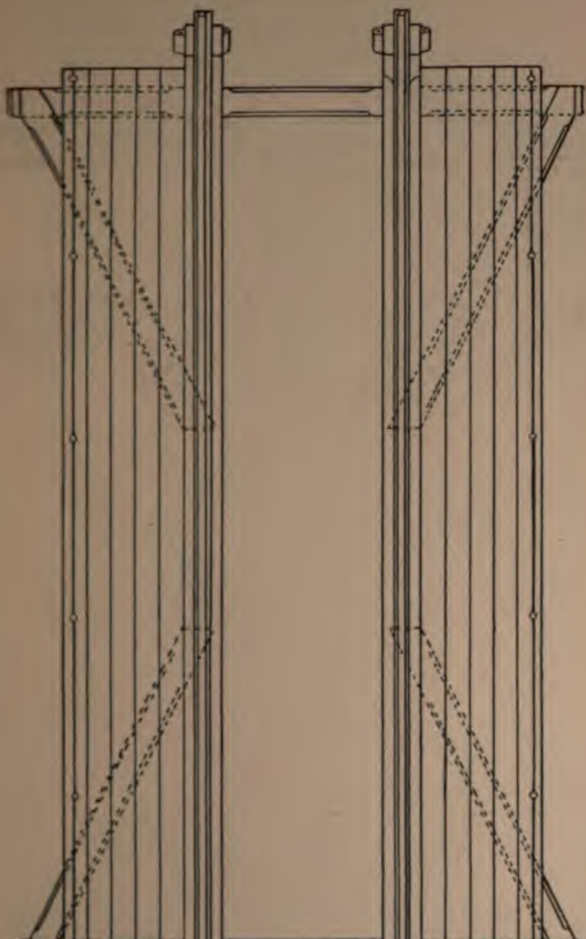


Fig. 126.

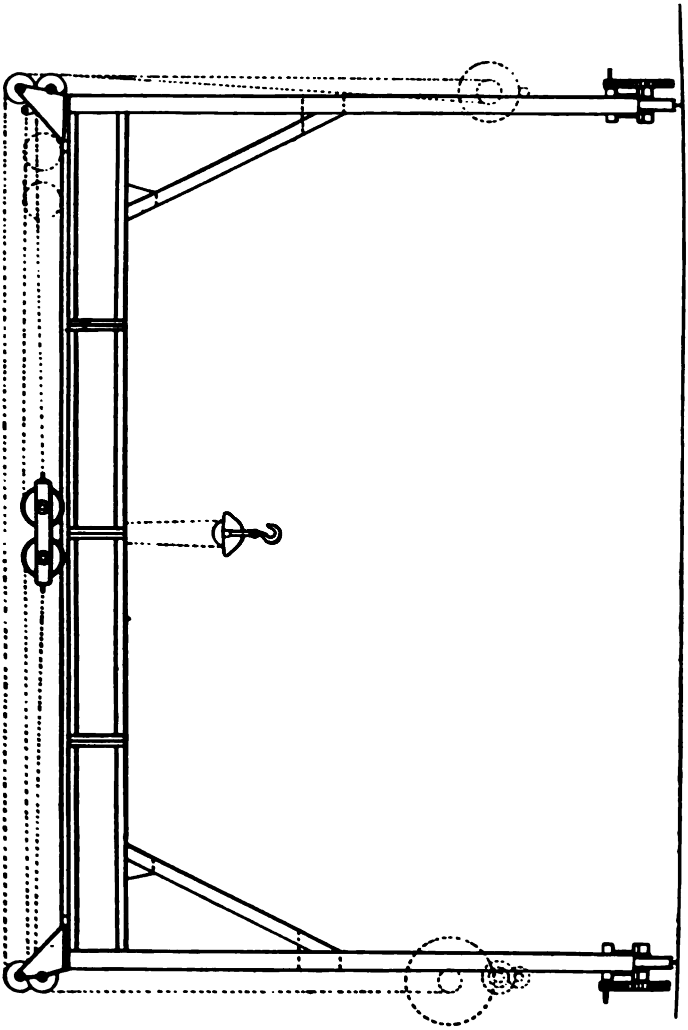


Fig. 127.

rails. In the figures the end framings in themselves are entirely rigid; the weak points are the attachments of the main beams to the A frames.' To stiffen these against a working to-and-fro at right angles to the track, which is very noticeable in steam-driven crabs, large diagonals are

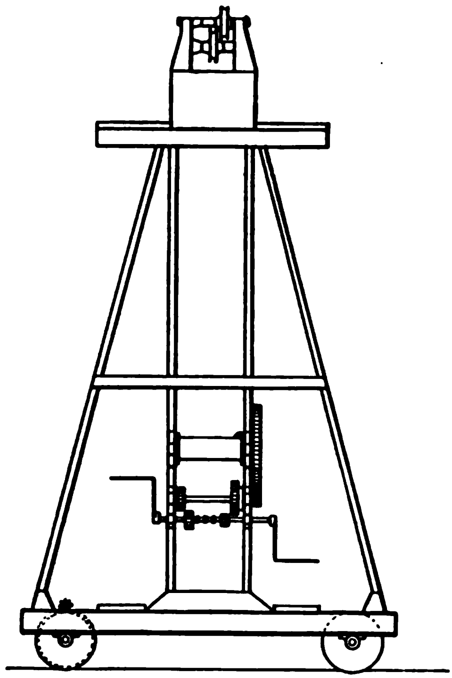


Fig. 128.

fitted between the main beams and the members of the A frames. To stiffen them against diagonal or cross working, diagonal struts are fitted between the under sides of the main beams and the tops of the horizontal members of the A frames.

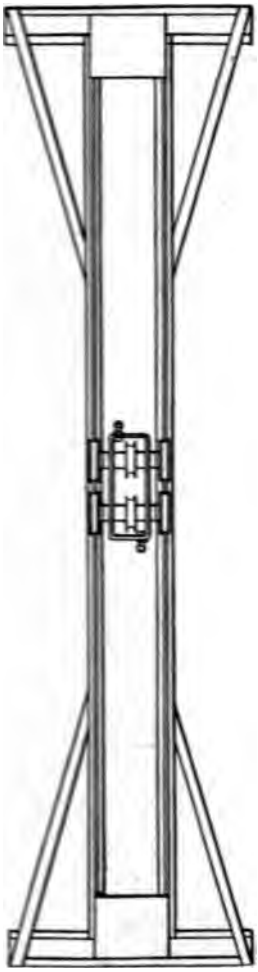


Fig. 129.

The details of the fitting of these and of other members are rendered clear by the drawings, so that little reference thereto is necessary. Tenons and mortices and shouldered joints are the rule, and long bolts unite every portion. Broad timber washers support the bolt heads and nuts.

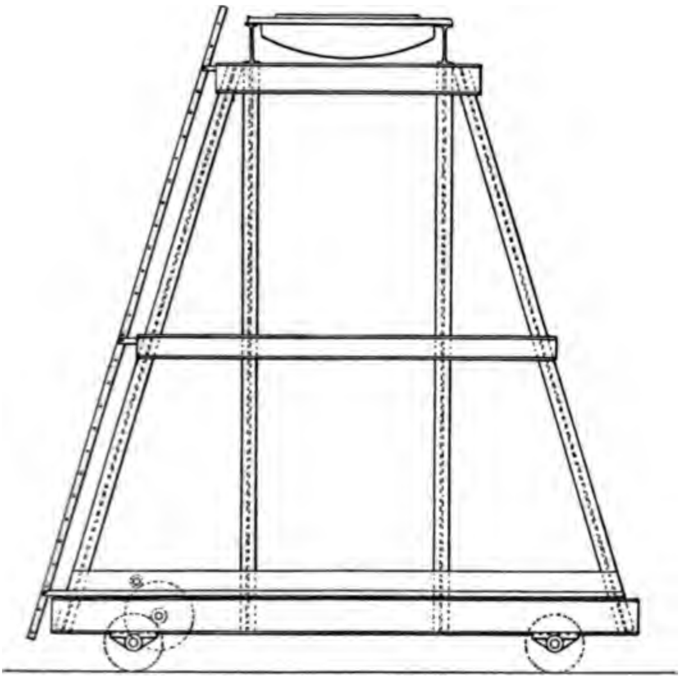


Fig. 130.

The main beams are fastened down to the A frames with long strap bolts. The ends of top and bottom sills are bonded. The ends of the main beams have cast-iron caps with stout lugs through which the truss rods pass. The centre strut is a casting. Platforms, protected with

hand rails, are carried on plated brackets at the sides of the main timbers.

Figs. 127-129 illustrate framings of steel built of channel and H sections. The same principles are embodied as in the timber structure, modified by the differences in the material, and the methods of union proper for each. Fig. 130 is one view only of the steel framing for a Gantry crane.

CHAPTER IX.

THE FRAMES OF OVERHEAD CRABS AND JENNYS.

General Design of the Crab—Of the Jenny—Their Special Utilities—Cheeks—Diversities in Design—Cast, and Plated—Methods of Operation—The Hand Crab—Details of Typical Arrangements—The Steam Crab—Cotton Rope—Electrical—Converted—All-Electric Types—The Jenny.

THE remarks offered in Chapter IV., p. 43, on the cheeks of cranes will apply in a large degree to the frames of crabs and jennys. Both are made in cast iron, and also steel plated. So that our attention will be given in the present chapter chiefly to the general design of the crab and jenny frames as affected by the difference in the functions of these, and of the frames of the true cranes.

An overhead crab is a special type of hoisting machine which has no jib, and the load is lifted directly underneath, about the centre. It differs from the fixed crab in the fitting of four wheels which run along rails on its traveller beams. It may be operated by any of the agencies common to cranes, and its form and gears are greatly modified by the utilisation of one or of the other of these agencies.

The difference between a crab and a jenny, or jinny, or trolley, or monkey carriage, or racking carriage ;—terms applied indiscriminately to the jenny,—is this. The crab carries its own operative gears, the jenny does not. Consequently though both travel along rails, the first is moved by its

own self-contained gearing, while the second is drawn along by chains which are actuated by wheels that have their bearings elsewhere, at the end of the beams of travellers, or on the A frames of the Goliaths. Just which is the more suitable method is often an open question, and practice is divided. For light and heavy loads alike both systems are in use. Speaking very broadly, it is better to use the simple jenny for light travellers, and crabs for the heavier ones. Even in the latter, however, there are cases in which heavy travellers are fitted with jennys, which in long spans impose less of dead weight on the beams of the traveller, or Goliath, than a massive crab would do, with its gears, and often also an engine and boiler. The latter add so greatly to the load that several firms have long made a practice in heavy travellers of putting engines and boilers at the end of the beams, and running a comparatively light trolley along them.

The cheeks of jennys and crabs are usually made in cast iron, the larger types alone excepted, and for the same reasons which were previously given. They follow in the main the designs of those of cranes. As previously stated, calculations are not readily applied in such cases, and experience takes their place.

The designs of crab cheeks, both cast and plated, are modified in so many ways that it is only possible to allude to these in very general terms. In the smaller powers they are single webbed. But in larger sizes, double webs are usually employed. When cast they are of the boxed form, similarly to some crane cheeks, a design which is neat as well as very rigid. In some steel-plated cheeks also, the plates are double, separated by distance pieces, also a very excellent method, having the merit of rigidity, and permitting of the use of bearings which are nearly flush with the outer faces instead of standing out away from one, or both faces. In some crabs the cheeks are formed of rolled joists, in others of built-up solid-plated girders. The different ideas of manufacturers are accountable for many of these diver-

sities in design, but underlying all these there are common objects in view. The two predominating factors are reduction in dead weight, and economy of manufacture. Some try to attain this in well-thought-out designs in cast iron, others in plated cheeks. In some cases the class of work to which a firm is committed, or in which they have gained most experience, is the determining factor. Thus, a firm dealing largely in castings will favour cast-iron cheeks, one which is more successful in plated work will give the preference to plated cheeks. Actually, excellent designs are produced in each, so that no absolute preference can be given to either without knowing by whom they are built. This, apart from inspection, is still often the best guarantee of the good design of a crane.

The cheeks of crabs are maintained at their proper distances by stretchers or distance pieces, which are simple bolts in small types, and cast girders, or rolled joists, or plated joists in the higher ones.

The remarks made in reference to the wheels of cranes, pp. 87 to 90, and travellers, p. 103, apply to crabs also. Shaft bearings are modified as in cranes.

The methods by which hand crabs are operated are very simple. The methods of operating power crabs are more complex, and subject to great variations. The general system of gears is treated in Chapter X., p. 130, to which reference should be made. The remarks made here assume that the problems involved in trains of gearing are understood.

In the simple hand crab, all the movements of the crab, and frequently also those of the traveller, are derived from the power of a man, or men actuating the winch handles. The lifting mechanism includes single gear only in light crabs, but in all others double; and in the heaviest, treble gears are included. Lowering may be done by the reversal of the direction of movement of the handles, but generally the load is allowed to descend by its own weight, its movement

being controlled by the application of the brake. During lifting, if the load is heavy, the ratchet dog is thrown in; during lowering it is thrown back, and the first motion pinion is slid along out of gear, so that the descent of the load is regulated by the brake entirely.

The last element in the train is the lifting drum or barrel, see Chapter XI., p. 149, whence the load is lifted on single chain for loads ranging up to from about 3 to 5 tons, or on

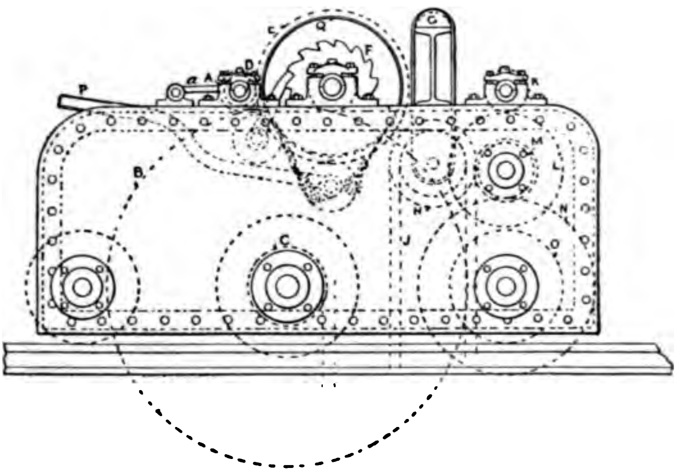


Fig. 131.

double chain, and snatch block, see p. 170, for greater loads. In small crabs the drum is generally plain, in others it is usually grooved. It is, or always should be grooved when wire rope is used, and its diameter must be larger for rope than for chain. The reason for grooving large drums, whether for rope or chain, is partly to prevent overriding, but also to maintain the load centrally in relation to the crab, see p. 150. When a return chain is used, one end has to be anchored from a beam overhead, Figs. 131, 132,

or it has to wind round a second drum ranged parallel with the main drum. Another set of gear is used for traversing the crab along the traveller beams. This may be simple, or compound, depending on the mass to be moved, and it is actuated by separate winch handles in hand crabs. The movement of the gears is communicated to a toothed wheel on the axle below, and so revolves that axle, and its wheels on the rails. The other axle is a trailer only. In

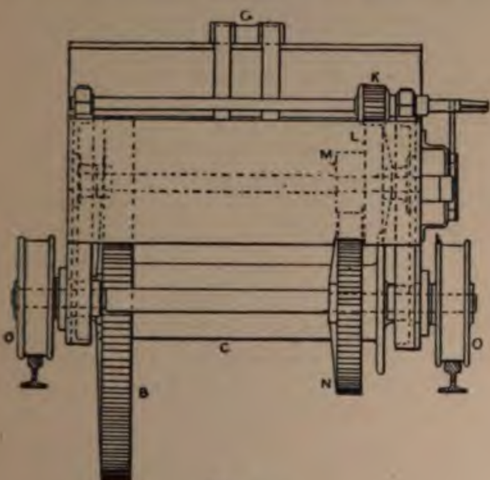


Fig. 132.

heavy steam crabs, front and rear axles are coupled with a rod, like locomotive axles.

Figs. 131, 132 represent typical arrangements for a hand crab with steel-plated cheeks, and employing a snatch or return block. In this example some of the shaft bearings are plummer blocks, others are bosses. The quick-lifting gears are pinion A, and wheel B, the latter being keyed on one end of the barrel C. D, E, and the pinion on the same shaft as F are the train of slow gears, G is the pillow block

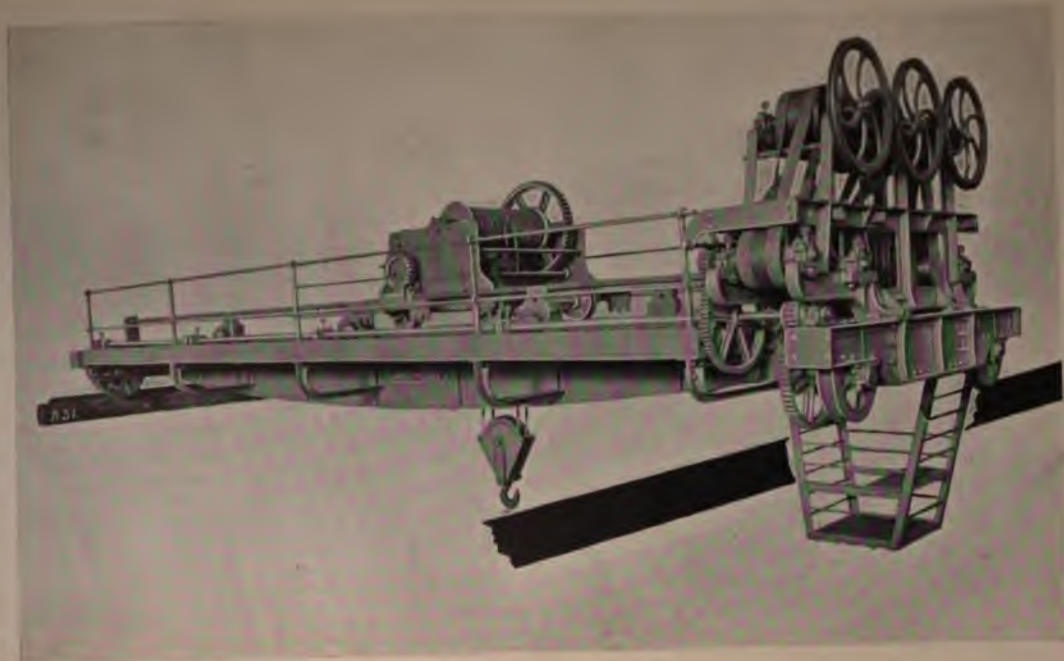
carried on a rolled joist that spans the cheeks, and from which the straps and blocks are suspended to carry the loose pulley H, which takes the upper bight of the chain J, one portion of which is anchored to the snatch block, the other portion passing under its pulley. The wheels K, L, M, N form the double set of gears for travelling the crab. The location of the brake is also indicated at Q, and its lever at P. As the gear of this crab is illustrated in detail in Chapter X. on Gears, p. 137, nothing further need be added here.

An overhead crane may be travelled from the crab, through gears actuated by a winch handle at one or at both ends of the traveller. When travelled from the crab, a square shaft is used to transmit the motion from the crab to the wheels on the end cradles. This is accomplished through bevel wheels carried in a bracket on the side of the crab, the last bevel in the train having a long sleeve bearing in the bracket, and a square hole to slide along the shaft, see p. 144, actuating the latter at any locality in which the crab happens to be.

In that type of steam crab in which the boiler and engines are placed on the crab, the arrangements are in the main similar, except that the crank shaft of the engines is the first motion shaft, whence all the various movements are derived through gears. The engines are duplicated, to avoid dead centres. Provision is made for single, double, and frequently treble powered lifts, for lowering by the brake, for traversing the crab on one of the axles, to which the other axle is coupled, and for travelling the entire crane through a square shaft.

In steam travellers which have the boiler and engine fixed at one end, there is no crab, but a jenny only.

In travellers driven by cotton rope the crab is still employed, but it is very much modified. Belt-driven shafts are actuated from the rope, and transmit motion to two shafts running longitudinally above the traveller beams, whence the lifting and traversing motions of the crab are



Overhead Rope-driven Traveller.

[To face p. 12

types, used on a single rail traveller. There is no gear sav that which is comprised in the tackle, and no means o traversing the jenny save by hauling at the block chains.

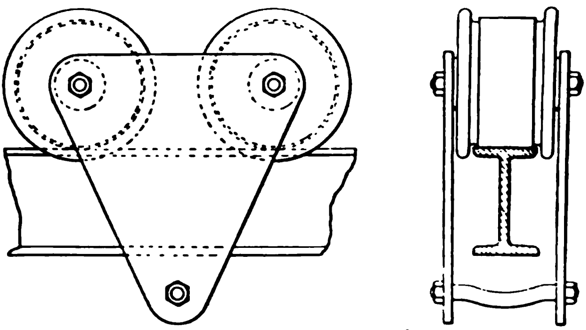


Fig. 133.

A true jenny is that which is made the medium for hoisting and traversing through toothed gears, which are nevertheless situated at a considerable distance away from it

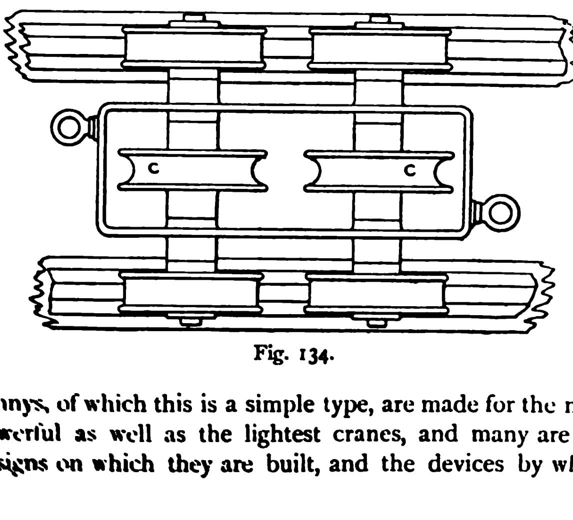


Fig. 134.

Jennys, of which this is a simple type, are made for the most powerful as well as the lightest cranes, and many are the designs on which they are built, and the devices by which

they are operated. An example of this kind was shown in Figs. 127, 129, pp. 116, 118, and the jenny is shown enlarged in Figs. 134, 135. It is drawn along by one set of gearing on one standard of the Goliath, through the chains A, and the

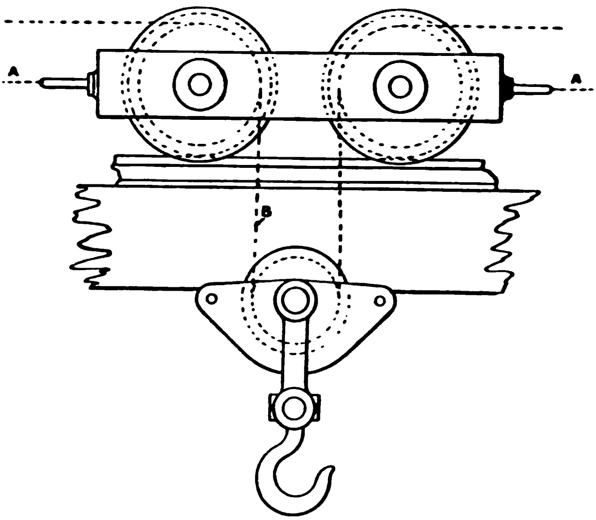


Fig. 135.

load is lifted and lowered through another set of gears operating the chains B, passing over the two pulleys C, C. The racking chains and lifting chains never run foul of each other because the eyes for the attachment of the former are placed away from the centre of the carriage, Fig. 134.

[redacted]

CHAPTER X.

THE GEARS.

The Forms of Teeth—Conditions of Gear—Cycloidal and Involute—Generating Circle—Small Pinions—The Case of Special Gears—Proportions of Teeth—Machine-moulded Wheels *versus* Pattern Gears—Arrangements of Wheels—Regarded as Levers—Winch Handles and Drums—Single Gears—Sliding Pinions—Typical Trains of Wheels—Transmission of Power at Right Angles—Wheels in Steam and Hand Cranes—Quick-running Gears—The Use of Steel—The Curb Rings—Their Sectional Forms—The Fitting of same—Derricking Gears—Reversing Bevels—Square Shaft Gears—Shrouds and Friction Collars—Ratchet Wheels.

THE gears of cranes are one of the fundamental sections of these structures, second only in value to the strength of framings and main parts. It is of the first importance that the wheel teeth should be correctly formed and proportioned, and accurately constructed. Badly formed gears, running at quick speeds, are not only noisy, but also risky. The fracture of two or three teeth may result in a serious accident.

First as to the forms of teeth. These are too often made by mere rule of thumb, but should be so correctly shaped that the wheels will roll smoothly with the minimum of friction. The fundamental principle of such mutual engagement of teeth is that the total effect shall be identical with that of the rolling of cylindrical surfaces upon each other. Actually, in all wheel teeth as commonly formed, a certain amount of rubbing and sliding of the flanks must take place, but the better the teeth are shaped, the less injurious the rubbing becomes. This is capable of com-

plete demonstration, but the proof would be too long, and scarcely within the range of the present subject. In practice the conditions of accurate gearing are fulfilled by the use of two curves, the cycloidal, and the involute. Of these the former is the more generally used. In the latter the tooth flanks are formed as by the unwinding of a rigid cord from the periphery of a cylinder (the base circle of the wheel). Or, what produces the same result, by rolling a straight-edge round the base circle, and developing the involute curve by a needle point driven diagonally through the edge of the straight-edge, Fig. 136. In the cycloidal, suitable curves are developed by the rolling of generating circles, A, A, Fig. 137, upon circles B (the pitch lines) of the wheels, and then finding by trial the nearest approximate radii *a*, and *b* for the curves of the faces and flanks of the teeth.

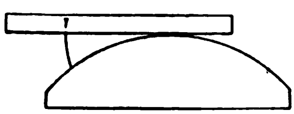


Fig. 136.

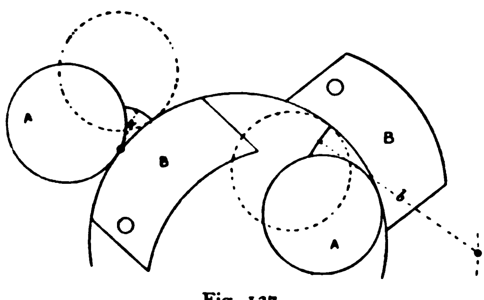


Fig. 137.

The principles of correct gear are present in each case, subject to certain conditions. The involute has been seldom employed for crane gears, partly on account of its want of adaptability, wheels only working with one another when the true circles are cut by a tangent line common to both, which is not conducive to the interchangeability of a

number of large wheels and small pinions, such as are required in crane gears. Recently, however, a considerable number of wheels are being cut with involute teeth for electrical cranes, in which the conditions of interchangeability are less exacting than for general and miscellaneous service.

In the cycloidal teeth, all that is necessary to fulfil these conditions is, that the same generating circle which strikes the roots or flanks of the teeth of one wheel shall be employed to strike the points or faces of the teeth of the wheel which has to gear therewith, and *vice versâ*. The profiles of the teeth are thus governed entirely by the diameters of the generating circles, and the selection of one size of generating circle ensures interchangeable wheels, so that any wheels of the same pitch can be taken from the stores with the certainty that they will gear equally well, a 60 tooth with a 10, or a 12 tooth with 96, or 15 with 114, and so on, all capable of gearing together correctly even though they differ much in strength, and in extent of surfaces in contact. This can only be possible by employing a common size of generating circle. If one is chosen of such a size that it will produce radial flanks for the smallest wheel of a set, that is the one which should be properly used for all the wheels which are ever required in practice. Though a disadvantage is that the roots in all small wheels are then much weaker than the roots in the larger ones, yet it must be remembered as a set-off against this, that small pinions can usually be shrouded, and that when worn out or broken they are more readily renewed than the wheels. Wheels smaller than 10 teeth are seldom used in crane practice. Actually in Willis's Odontograph scale, the limit is fixed at 12 or 13 teeth, hence these have radial flanks, and any below that number would have convex and undercut flanks, curving inwards less than radial; and all above, spreading flanks, the enlargement at the root increasing with the

diameter of the wheels, until at 80 or 100 teeth we have very strong teeth.

There is no difficulty either in using the rolling circles directly, or in employing the Odontograph scale, by which approximate radii and centres are obtainable directly for wheels of almost all sizes. Though weakness of the roots of the small pinions is unavoidable, yet for special gears, as bevel wheels, where it is certain that no other wheels will ever be introduced, special generating circles can be selected with reference to the best forms of teeth obtainable for those wheels.

The proportions of teeth for the same pitch should always be alike. These are given in various text-books, and will not be gone into here. But it is right to mention that the older proportions which gave long teeth are now generally discarded in favour of short teeth, the length of which does not exceed from six-tenths to seven-tenths of the pitch;—which must be measured round the arc, and not along the chord. This reduced length is desirable, in order to diminish the risk of fracture. If it is objected that shorter teeth would be liable to get out of gear and override when shaft bearings become badly worn, such bearings should not be tolerated on any crane.

As far as practicable, castings should either be machine-moulded, or else moulded from iron patterns, which have been made in a moulding machine. If complete wood patterns are used, the teeth should be machine cut, besides which they must be checked over from time to time, and kept in good preservation. But even then wooden pattern wheels do not give such good results as the first named. True, some machine-moulded wheels are as unsatisfactory as those moulded from wood patterns, which happens when badly worn tooth blocks are retained in use, or the machine is worn, so that slop and backlash occurs, or when the moulding is done by a careless or incompetent man. These three matters,—good blocks, an accurate machine, and a

competent careful moulder, are each essential to the casting of accurate gearing. Given these conditions, machine-moulded gears are for all practical purposes nearly as good for cranes as those which are machine cut. But such gears are rather costly, because only from two to three tooth spaces are moulded at once. Hence moulds taken from iron pattern wheels which have been moulded by machine give very close approximation to accuracy. They are not quite so good, because a little taper has to be filed in the teeth to ensure their withdrawal, and then generally some slight breaking down occurs in the mould, which has to be made good (unless the pattern is drawn through a stripping plate), and by which the perfect form of the tooth will be impaired. Still, as such patterns never wear or get out of truth, they are not open to the same objections as wood patterns are. The rings only of such wheels need be made in iron, the arms and boss being made in wood to fit within the rim.

We may next consider various arrangements of the gearing which are adopted to produce given results in power, speed, and in the operation of the various movements of cranes.

Many circumstances have to be considered in designing these arrangements, as the general or average run of work for which the gearing will be primarily designed, work of an exceptional character, for which provision must be made, the class of crane, the space available, &c.

Toothed wheels act as straight levers in which the mechanical advantage is in inverse ratio to the length of their radii. But radii, diameter, and circumference being proportional to one another, it follows that either dimension as most convenient may be taken as the basis of calculation, if the same factor is retained for all the wheels of a series. Further, as levers, the wheel will represent the long arm, and the pinion the short arm of a single straight bar, and its fulcrum will be the pitch line of the pair. Hence if the

pinion is the driver, there will be a gain of power; if the wheel be the driver, there will be a gain of speed, in both cases of course inversely proportional to their radii. Applying the principle to a train of crane gearing, we can understand the ease with which a couple of men can lift a couple of tons without any excessive expenditure of muscular energy, simply employing the intervention of a train of gearing. Taking a common crane, let the gear comprise pinion A of 15 teeth, wheel B of 136 teeth, pinion C of 15 teeth, and wheel D of 91 teeth. A pound weight acting on the periphery of A would represent $\frac{136}{15}=9$ lbs. on B. But C and D form another pair of levers, and their gain is $\frac{91}{15}=6$. And since the mechanical effect of two levers is not the total of their added results, but of those results multiplied, we have $9\times 6=54$, so that 1 lb. on A will raise 54 lbs. on D, friction disregarded. Or we can multiply the teeth of the wheels of a train together, and also the teeth of all the pinions together, and divide the former by the latter to arrive at the same results, thus,—$\frac{136\times 91}{15\ \times 15}=55$. Not exactly the same, because the figures are not worked into decimals. To apply the necessary power at one end, and to utilise the mechanical increase at the other, various means are adopted. In the first a winch handle, steam, water, or other power will be applied; in the second a barrel or drum is employed. But these also increase leverage. A winch handle measuring 16 in. from centre of shaft to centre of handle will be a lever 16 in. long evidently, so that for every pound applied at the handle the first pinion will receive a force of 16×3.1416 which represents the circumference of the circle which it describes. The barrel also forms a lever with its wheel D on the shaft of which it is fixed, so that the calculation stands—

$$\frac{\text{circ. described by winch}\times \text{A}\times \text{C}}{\text{B}\times \text{D}\times \text{circ. of barrel}}$$

(In practice the circumference taken is not that of the barrel, but of the centre of its chain.)

The simplest gear then which can occur is that of the pinion and wheel, termed the single gear. This is suited for light loads, and quick speeds. It is fitted to all hand cranes, and most of the small steam cranes have no other. All travelling cranes have it, and all hoists, whether hand or steam. Loads up to 2 or 3 tons can be lifted in this way.

When a crane has single gear only, there may be modifications in detail. Thus, using winch handles, from one to four men may operate on them at one time. With engines, speed may be increased by opening the starting valve to its fullest capacity, and using steam at highest pressure. In either case the relations between the pinion and wheel may be of a high or low ratio. Also the diameter of the hoisting drum may be small, large, or medium, for heavy loads and slow lifts, or for the reverse. Small drums are often used on quarry cranes and hoists, large ones on light coaling cranes. In single-geared cranes, the brake goes on the same shaft as the wheel and drum, often on the wheel itself. It is then desirable to make the pinion to slide in and out of gear, because it is better when lowering with the brake to avoid wear and tear, and rattle, by allowing the wheel and drum to revolve only. When the pinion cannot be thrown out, the handles of a hand crane must be taken off before lowering. In a steam crane, if there were no sliding pinion, the lowering could not be done by means of the brake, but the engines would have to be reversed, and the load lowered by them. This would be a slow, noisy, and wasteful process.

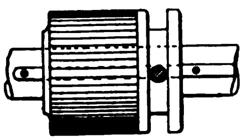


Fig. 138.

When the pinion is made to slide out of gear, it has to move along a feather key, and a collar or groove is provided at its end to receive the fork of the lever by which it is

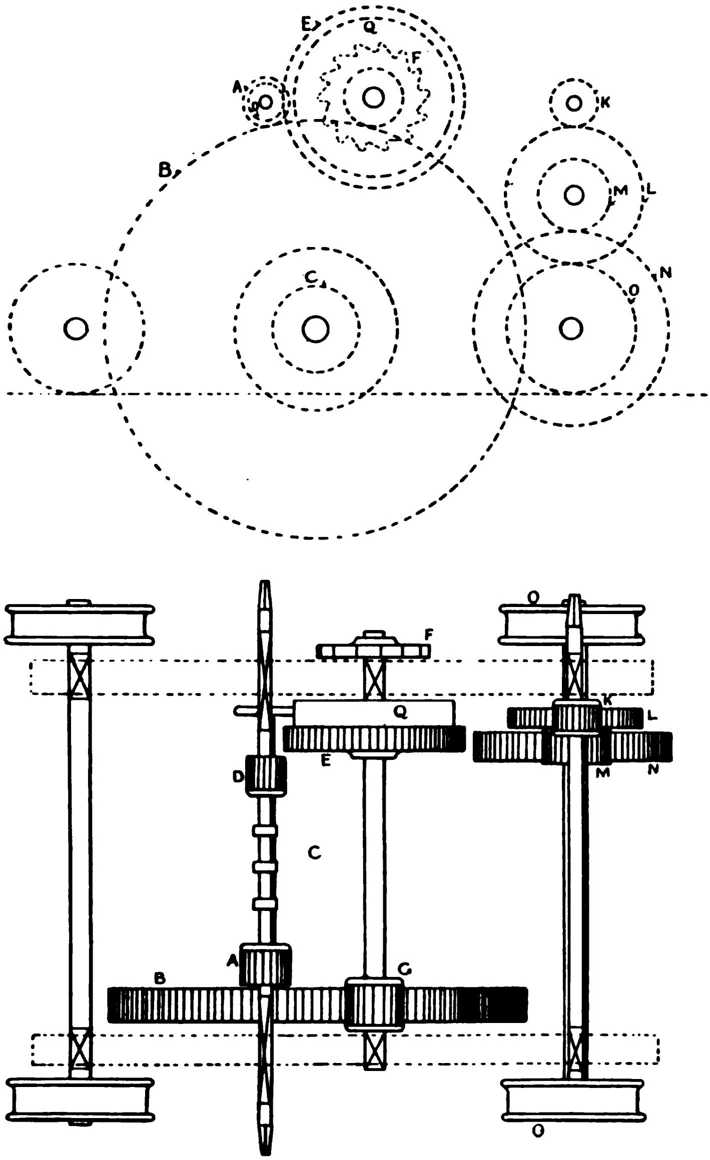


Fig. 139.

moved. Such a pinion is shown in Fig. 138. The teeth are often rounded or pointed slightly at the entering end in order to facilitate free entry without risk of knocking off the tooth points.

The mechanism by which pinions are slid into and out of engagement with their wheels is either by means of a feather on the shaft, by which the pinion is slid and driven at any position as in Fig. 138, or the shaft slides with its pinions. The first method is suitable for hand and power cranes, the second for hand cranes alone. An illustration of the latter is seen in the crab gears, Fig. 139, where pinions A and D are keyed on one shaft, and A can be slid into engagement with B, or D with E by the endlong motion of the shaft. A pawl is dropped between the collars on the shaft to retain either pinion in gear, or to keep both out of gear when lowering is being done by the brake, as in the position seen in the figure.

The gears in this figure afford a good illustration of the combinations which are found in various modifications in nearly all cranes. When A is in engagement with the wheel B, the latter lifts a light load on the barrel C, on which it is keyed, at a quick rate. When D engages with E on the same shaft as G, the latter drives wheel B, and the drum C slowly. When lifting, the ratchet wheel F is retained by its dog, so that the load will be sustained if the handles should slip off, or any accident happen. Lowering is done by the brake Q cast on wheel E, the pinions A and D being in the middle position shown, the pinion G always remaining in gear with B.

The gears to the right hand are used for travelling the crab. The pinion K, turned by winch handles, engages L; and on the same shaft as L, M drives wheel N on the same axle as the driving wheels O.

Transmission of power at right angles is common in nearly all cranes fitted with travelling and slewing motions. This is mostly effected by bevel gears, less frequently by

worm gear, and occasionally by angle wheels. The first named offers less friction than the others, and has the great advantage that any differences in velocity ratios, as well as equal drives, are easily obtainable. Very often two pairs of bevel wheels are necessary, but when the number exceeds this, it is better to seek some more direct method of driving with less friction.

The worm gears are used more than ever, notwithstanding that they were nearly abandoned a few years ago by reason of the excessive amount of friction which they developed. But they are so valuable in the reduction of motor speeds in the electric cranes, and in smooth running, that the oil bath, friction collars, or ball races, and the use of double, or treble threads, has converted these into a most valuable and popular gear. The angle or screw gears are only suitable for very light duty, because the friction is entirely of a sliding character, and takes place at a single small surface of contact. Hence they wear out rapidly. They have been used for the slewing of light cranes, but were not satisfactory.

The lifting gear of steam cranes differs from that of hand cranes in this particular, that much heavier loads can be lifted with single gear in the former, than in the latter,—due to the greater power in the engines than in that which can be exercised by men at winch handles. The gain is also greatly in favour of speed as well as of power, so that loads are hoisted rapidly by single gear in steam cranes, which would be lifted laboriously and slowly by four, or six men at winch handles through double gear on a hand crane. In steam cranes lifting over about 5 tons, it is usual to put double gear, but seldom under 5 tons.

It is of course more necessary to put good gearing on quick-running cranes than on hand cranes and crabs. In these, when inferior gears are used, their defects are largely disguised by the slowness of the movement. But this does

not justify the use of bad gears. In steam and electric cranes the high rates of speed cause some rattling even with the best moulded, or even cut wheels, due to the sonorous character of metal. With badly formed teeth the rattling becomes intolerable. And it is not altogether a question of noise, but also one of strength and durability. Badly formed teeth receive stresses under unfavourable circumstances, and they wear out quickly, and in some cases fracture.

The employment of steel for gears is very desirable in cranes which have to do a deal of rough work for which both strength and durability are desirable. They cost double those of iron, but they last more than twice as long. Nor is that the only advantage. The liability to fracture is so slight, that the risk of stoppages of work for repairs is much lessened. When steel gears are used it is desirable to keep duplicates, because, unlike iron, steel wheels cannot be obtained in less than from two to three weeks.

In all the gearing of a crane there is none subject to so great stress as the curb ring, or wheel race. The whole stress of turning the crane with the maximum load at the maximum radius comes upon this. And it is not so much the actual turning as the sudden starting and stopping that stresses the ring. The teeth of this ring wear more rapidly, and fracture more readily, than those of any other part of the gear, and sometimes rings will fracture across under the severity of their duty. Then the crushing stress due to the pressure of the whole superstructure, and of the load on the rollers, wears the surface rapidly, causing the thickness or depth of the ring to diminish. The following are the precautions taken to prolong the life of the curb rings of cranes.

Cast iron is always used, unless otherwise specified, but steel is much to be preferred, because of its greater strength, and capacity for wear. Often after the purchase of a crane fitted with a cast-iron ring, a steel ring is ordered,

and then that means lifting off the whole superstructure to put the new ring into place. In many cases, however, this involves so much trouble and delay that rings are made in halves, and cottared together. The ring, however, is cast entire in order to preserve its circular form. It is then parted off in a slotting machine with a $\frac{1}{4}$ in. or $\frac{3}{8}$ in. tool. Circular holes are drilled in from the joint faces, and cottar ways drilled down through them, packing pieces are inserted in the joints, the round pins placed, and the cottars driven in, so drawing the joint together. Such a ring is easily inserted and cottared up, and as easily removed without interfering with any other part of the crane.

The forms of the teeth are best if struck with Willis's Odontograph scale, because that gives great breadth at the roots. Then the roots should be merged into the rim with specially large radii. No stronger form can be designed.

The teeth of the pinion that engages with the ring will be weak at the roots, but these are always shrouded on the top face, and often also cast in steel, occasionally in phosphor bronze, which wears excellently. The curb ring should be machine-moulded in order to secure the best conditions of working. Steel curb rings are liable to come out elliptical in form instead of truly circular as they ought to be. They can be made circular if the moulder clears away the sand from the inner vertical faces of the runners. It is the resistance of the hard mould to the massive runners during shrinkage, which interferes with the regular shrinkage of the ring all round. In the iron foundry the sand is dug away from the runners as soon as the metal has set after pouring.

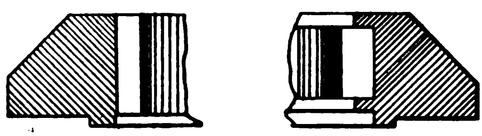
The sectional forms of curb rings shown in adjacent figures, Figs. 140, 141, are used on hand cranes, but lack the strength necessary for steam cranes. Figs. 142, 143 are used for steam cranes. The bevelled face in these is

turned to form a path for the rollers upon which the superstructure rotates. There is usually a slight coning on the rollers and path. The angle on the faces of the rings is governed by the arrangements of the superstructure. In Figs. 140, 142, 143 the teeth are internal, in Fig. 141 external. Both methods are in use, and neither has any particular advantage over the other, except in so far as

Figs. 140, 141.

one happens to be more adapted to the arrangements of a given crane than the other.

The method of fitting the ring to its bed is with a circular check or shoulder turned to fit a corresponding shoulder on the face of the bed. Many curb rings are bolted down to the bed. This, however, is not a good plan, and one of the crane-making firms conceived the idea of omitting the bolts altogether, leaving the fitting in other respects the same.



Figs. 142, 143.

Many rings are now fitted thus, and it is found that the teeth are less liable to fracture under the stress of sudden starting and stopping, while the frictional surface of the ring is sufficient to prevent it from slipping under ordinary conditions of working.

The derricking gear of cranes is operated by a worm and worm wheel, the worm being single threaded. There is

always a good deal of friction about this gear, so that under ordinary conditions there is never any risk of running down occurring. Yet it is sometimes the practice to put a brake on it. The reason is to be found in wind pressure, and the vibration due to working which causes tremor in the gear, and makes it slip. A brake when used prevents this movement.

The direction of motion of bevel wheels has to be reversed when they govern the lifting and lowering of loads, the slewing of cranes, and travelling motions. This is accomplished by the device shown in Fig. 144. Two bevel wheels A, A with clutches, run loosely on their shaft, each

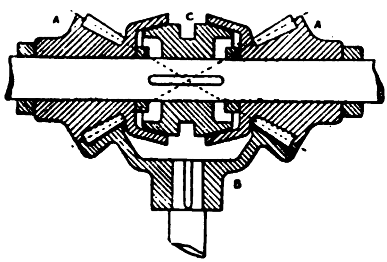


Fig. 144.

engaging with the crown bevel B, which may be used to drive above or below, or at any angle thence to the horizontal, according to the arrangements of the crane. A double-ended clutch C capable of movement along a sliding feather in the shaft on being thrown into engagement with the clutch on either one of the bevel wheels, drives that wheel. Reversal is effected by coupling the clutch with the other wheel, when it is obvious that the direction of motion of the crown wheel will be reversed.

A particular case of gears is that shown in Fig. 145, used to transmit motion between wheels which are subject to longitudinal changes of position. These are used on travellers

having a square shaft A, as shown in the figure. In some examples a round shaft is substituted, and key-grooved or splined throughout its length. The wheel B comes from the

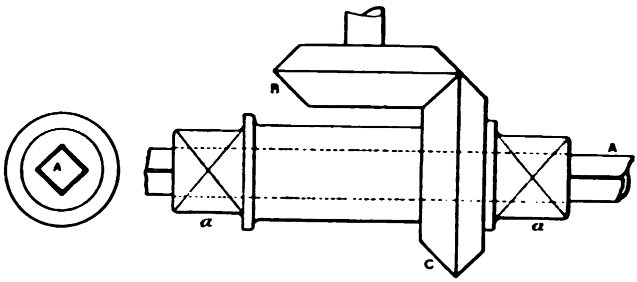


Fig. 145.

crab, having its bearings carried in a bracket attached thereto. Wheel C has its bearings *a*, *a*, in the same bracket, which is one reason why the long sleeve cast with the

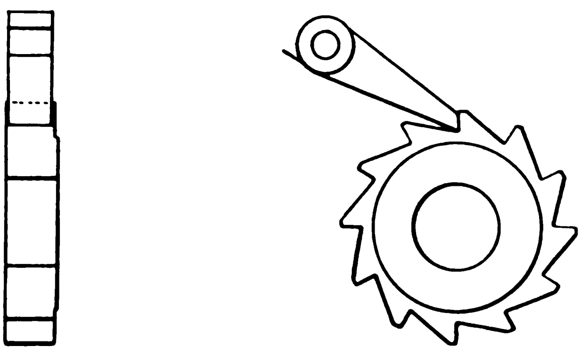


Fig. 146.

wheel is necessary, the other being to get a sufficient length of driving surface on the square of the shaft.

An important detail which adds to the strength of gearing, or conduces to smooth running, is the use of shrouds, or

friction collars. Small cast pinions are mostly single, or double shrouded; single when they must be slid into engagement with their wheels, double when they are never moved endwise, see Fig. 139, p. 137. The shroud or cap comes to the points of the teeth and strengthens them by perhaps 50 per cent. Friction collars, or half shroudings, come to the pitch line see Fig. 143, p. 142, in which case both wheel and pinion are similarly treated, and they run together with the turned edges of the shrouds in contact. Two advantages are gained, one in increase of strength, the other in smoother running. This is of especial value in high-speed gears, in bevel gears where the axes are at right or other angles and subject to much strain, and in specially heavy gears.

A ratchet wheel and its dog is shown in Fig. 146. These have to be strong enough to sustain the load, hence the reason for the triangular-shaped teeth, and their opposition to the axis of the dog.

CHAPTER XI.

THE SHAFTS, DRUMS, AND BRAKES.

Forms of Shafts—Keys—Pawls—Square Shafts—Drums—Plain—Spiral—Fusee—Warping—Castings—Brakes—Leverage of—Details—Electrical Brake.

THE shafts of cranes are usually made of steel in preference to the wrought iron formerly employed. Their diameter is increased from first motion to barrel shaft, and ranges from about $1\frac{1}{4}$ in. in the first motion shafts of the smallest hand cranes and winches, to 7 or 8 in. in the barrel shafts of the

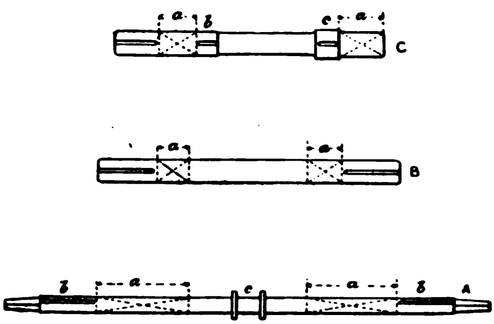


Fig. 147.

most powerful cranes. Standard dimensions are kept in crane shops, but diameters are obtained directly from the modulus of the section, as given in text-books.

Shafts are turned only where the wheels go on, in the cheapest hand cranes, but in all others they are turned throughout their whole length. Or instead, a good deal of

rolled bright shafting has been used recently. Shafts are key-grooved for wheels, and pinions, ratchets, and brake wheels, squared at the ends for winch handles, and have collars for pawls. Three typical shafts are illustrated in Fig. 147. A is a winch shaft, B an intermediate, and C a barrel shaft. The winch shaft A is of that type which is slid endwise, in the manner explained in Chapter X., p. 138. *a*, *a*, are the sliding lengths of journals, being of necessity long enough to permit of the engagement and disengagement of the pinions which are keyed on at *b*, *b*. *c* is the pawl space. The winch handle is shown in Fig. 148, its standard radius being 16 in. to 17 in. When first motion shafts have sliding pinions, the latter slide on feather keys, Fig. 138, p. 136. These are used on all power cranes, and on many hand-operated ones also.

The second or intermediate shaft B is usually plain as shown, with journals at *a*, *a*, but it may contain various dispositions of pinions. The barrel or drum shaft C is also variously modified, but the method of keying it in the drum which is indicated in the figure, compare with Fig. 151, p. 149, must be noted. The journal bearings *a*, *a*, may or may not be of the same diameter, but the shoulders *b*, *c*, which fit into the holes bored in the barrel ends, are properly of different diameters in order to facilitate the driving of the shaft into the barrel. *b* is smaller than *c* by $\frac{1}{8}$ in., or $\frac{1}{4}$ in., and therefore slips easily through the hole bored for *c*, and neither shoulder fits, or requires driving, until each enters its bored hole.

In fitting wheels on small shafts it is sufficient to have a key bed in the bore of the wheel, and to file a flat only on the shaft, and this weakens the latter to but a slight extent. But with the heavier wheels and shafts, sunk keys are employed, and then the weakening of the shaft is very considerable. Two courses are then open, either to increase the size of the shaft locally, that is just at the spot where the wheel is keyed on, or to increase it throughout

the whole length. There is little choice between the two, but the former would be cheaper when several crabs are being made, as costing less for metal; the latter when one or two only were wanted, because the value of the extra metal would scarcely exceed that of jumping up, or of welding collars on the shafts.

The barrel wheel is keyed either upon the barrel shaft directly, or upon the barrel itself, compare with Fig. 153, p. 151. The latter, though slightly more expensive, is the better plan, because the torsional strain on the shaft is lessened, the wheel forming an integral portion of the barrel; and the latter being keyed at each end much diminishes the torsional strain.

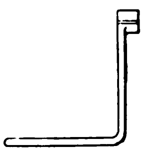


Fig. 148.

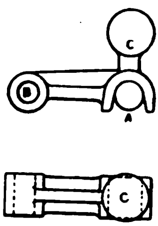


Fig. 149.

Fig. 149 shows one type of shaft pawl, A being the shaft. It is slid over a pin shaft, or spindle B, as most convenient. The weight C cast with it prevents the pawl from becoming jerked out of engagement with the shaft. Pawls are varied in form and proportions, and are most frequently made of steel and wrought iron.

Fig. 150 illustrates a detail in shafting adopted in jointing up the necessary length for a square shaft, as used for driving overhead travellers, and Goliaths. The ends of the lengths are scarfed in the manner shown, and united with four or more rivets, countersunk, and filed down flush to permit the sleeve wheel (compare with Fig. 145, p. 144) to slide over the joint as elsewhere.

The hoisting drums of cranes occur in many diverse forms, and are used under many conditions. They range from 6 in., to 8 or 9 ft. in diameter. They are plain, or grooved, the grooves being made to take either chain, or wire rope. The grooves run in one direction only, or right and left handed, or they are of fusee form. Drums are

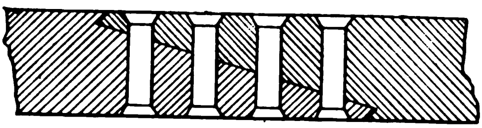


Fig. 150.

usually bored, and keyed on their shafts. In some cheap classes of work, small drums are cast upon their shafts. This is not a good practice, because it makes the shaft hard and brittle, and prevents the replacement of a worn shaft with a new one.

The diameter of the drum is one of the factors in the power and speed of a train of crane gearing. The smaller

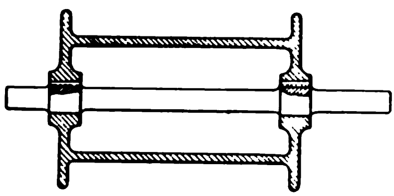


Fig. 151.

it is, the greater the power which it transmits from the toothed wheel keyed upon it, or on its shaft; the larger it is the quicker the rate of hoisting. Hence, the gearing remaining the same, the drums of all quick-hoisting cranes are larger than those for more powerful cranes.

Fig. 151 illustrates a plain drum used for chain, and

suitable for cranes of moderate powers. The proportions shown are good. The internal recessing next the bosses is done to prevent shrinkage strains which would occur if the ends were of the same thickness as the boss thickness.

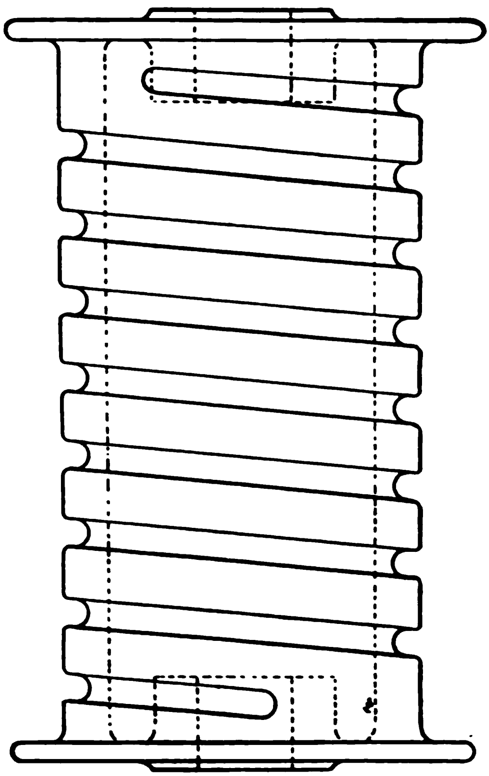


Fig. 152.

Fig. 152 is a spiral drum for chain, the chain links laying flat, and edgewise alternately; Fig. 153 shows a drum with right and left hand spirals, to lift the load always centrally. In these grooves the chain lies diagonally in the same position which it assumes on a plain barrel like Fig. 151.

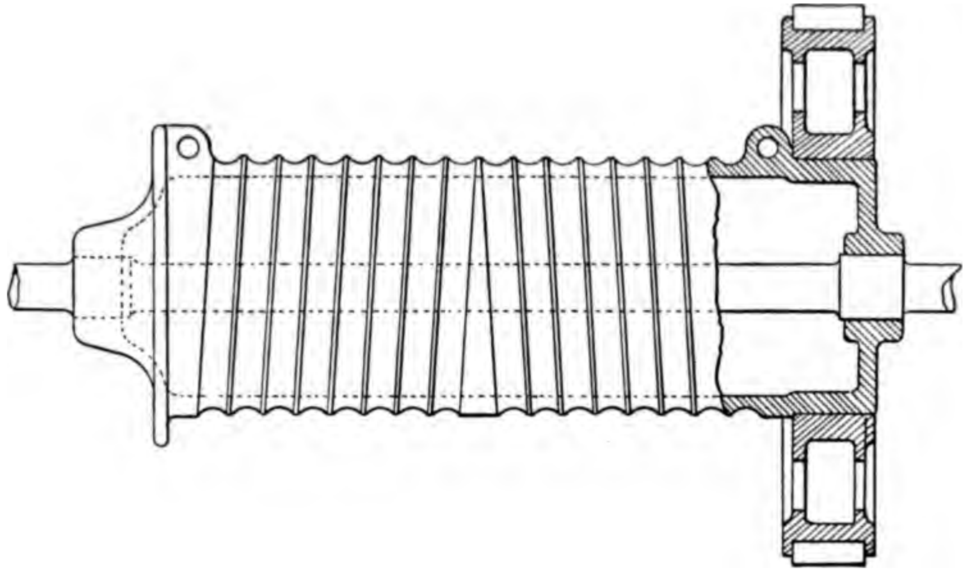


Fig. 153.

The wheel is keyed on the drum, and has friction collars, see Chapter X., p. 145. The lugs shown are for the attachment of the chain. The drums for wire rope have grooves of the same shape as those in Fig. 153, but narrower, to embrace about one-third the circumference of the rope.

Fig. 154 is a fusee barrel used for derrick cranes, the rope or chain used rising up on the larger diameter of the drum, and there coiling faster as the jib is hoisted up,—the effect is to keep the load approximately level at all radii of the jib. In Fig. 154 the ratchet wheel is cast on the drum, a common practice. Fig. 155 is a warping drum as used on steam hoists for hauling trucks along with a rope payed round the drum.

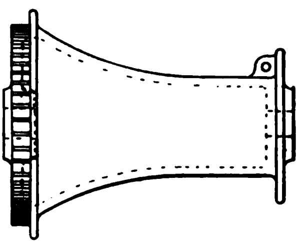


Fig. 154.

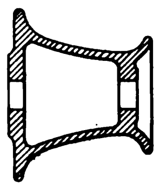


Fig. 155.

In the case of the plain barrels up to about 24 in. in diameter, entire patterns are used, above that dimension loam patterns are employed, or loam moulds are struck. For the barrels below about 24 in., standard patterns are kept for standard work. Even for cranes of standard type the diameters of the drums are often varied to suit different radii of lifts. And in miscellaneous work drums occur in all diameters and lengths. Since too these patterns occupy a considerable amount of store room, the practice is to keep a few barrel patterns of definite diameters as 10, 12, 13, 14, 15 in., &c., and long enough to include any length likely to be required, together with flanges of different

diameters, and make up any barrel patterns therefrom to definite dimensions when ordered.

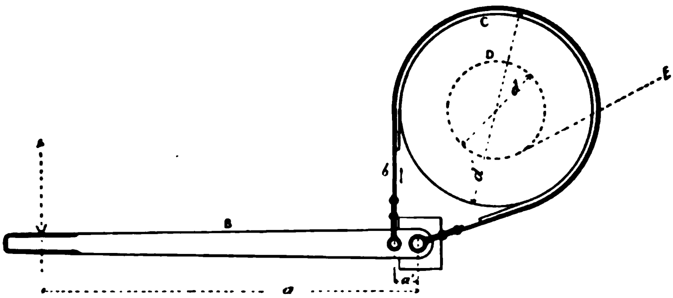


Fig. 156.

In most hoisting machines the load is capable of being lowered with the brake, that is, when the load is in suspension, it is capable of being so retained for an indefinite period by the friction of the brake. Also, by momentarily releasing such friction, the load can be released, and lowered to any required degree, minute or otherwise, and again arrested by putting on the brake.

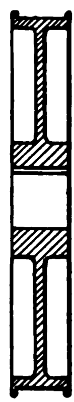


Fig. 157.

With few exceptions, the brake is simply a smooth turned wheel embraced by a strap of wrought iron, with, or without intervening flexible wood, or leather lining. Fig. 156 represents the usual arrangement, by which it is seen that immense leverage is capable of being exerted on the strap. The blocks are properly made of willow, or poplar, screwed to the wrought-iron strap. The lever is, in winches or cranes, worked by hand or foot, and it may be on the right or left hand side. The brake is either on the second, or the third motion shaft, to gain the greatest amount of power. It may be cast as a ring on the barrel wheel, or be

a separate ring with arms, and keyed on independently. The former is the plan to be preferred. Sometimes the brake is made to embrace the teeth of the barrel, but this is bad practice, wearing out the brake band rapidly.

In Fig. 156 the leverage exerted at A on the length a of the lever B sets up tension in the strap b, with friction

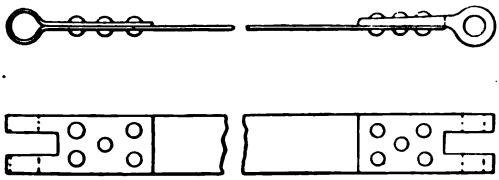


Fig. 158.

round the band wheel C, shown in this case on the same axis as the drum D, whence the load on the chain E is controlled. The power of the brake depends to a large degree on the portion of the circumference of C which is embraced by the strap b, usually about three-fourths. The load on the rim

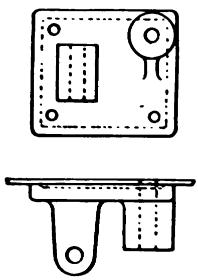


Fig. 159.

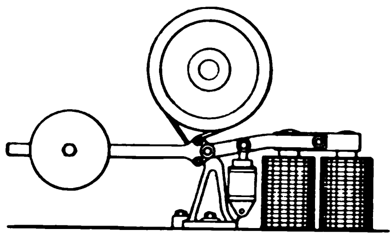


Fig. 160.

of C is found by multiplying the load on E, by half the diameter d of the chain centres of the barrel, and dividing by half the diameter d' of the brake wheel. If the circumference embraced is three-fourths, three-fourths of the result is taken, and divided by the leverage of the handle B, that is, of the length a over a', the final result giving the load

which has to be exercised on the end of B to measure the holding power of the brake.

Fig. 157 is a section through a brake wheel cast as a separate piece. Often, however, brake wheels are cast on toothed wheels (compare with Fig. 139, p. 137). Fig. 158 illustrates a typical brake strap. It is made of a strip of iron or steel, riveted to straps at the ends, with eyes for the brake pin. In the best brakes the straps are lined with short blocks of wood, from 3 to 4 in. wide, renewed when they become worn down. Leather is also used to a certain extent. Fig. 159 shows an anchorage for a brake, comprising a casting bolted to crane cheeks, the lug forming the anchorage, and the boss receiving the pin.

Fig. 160 is a typical magnetic brake, with two solenoids. When the current is on, it passes through these, holding down the keeper on the end of the lever, and keeping the brake strap off. Should the current be cut off, or fail from any cause, the keeper is released, and the counterweight instantly pulls the brake on. The action of the brake is prevented from going on with a jerk by a spring buffer in a box next the solenoids.

CHAPTER XII.

CHAINS, PITCH CHAINS, AND ROPES.

Type of Chain used for Cranes—Dimensions—Periodical Inspection—Taking out Twist—Plain *versus* Grooved Drums—Pitch Chains—Their Utility—Types—Hoisting by Pitch Chains—Wire Ropes—Diameter of Drum or Sheave—Care of Wire Ropes—Length of Splice—Cotton Ropes—Manila Ropes—Wear of Ropes—Length of Splice—Speed of Ropes—Diameter of Pulleys.

CHAINS and ropes are used for lifting and hauling, pitch chains for transmission of power at comparatively short centres. Ropes are used for transmission over long distances. Of late years there has been a growing disuse of chains for hauling in favour of wire ropes.

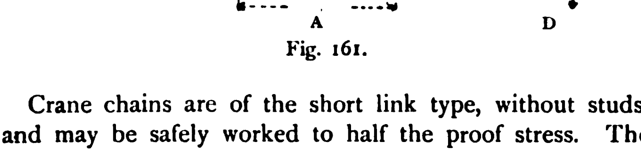


Fig. 161.

Crane chains are of the short link type, without studs, and may be safely worked to half the proof stress. The size is of course reckoned as that of the diameter of the iron from which the links are made, and the lengths and widths of links are given in proportions of the diameter,

Fig. 161. The annexed Table gives those proportions for chains ranging from $\frac{1}{4}$ in. to $1\frac{1}{4}$ in.

PROPORTIONS OF CHAINS.

Diameter of Iron.	A.	B.	C	D.	Loads at 5 tons per inch.
inch.	inch.	inch.	inch.	inch.	
$\frac{1}{4}$	$1\frac{1}{4}$	$\frac{7}{8}$	...	$\frac{11}{16}$	·49
$\frac{5}{16}$	$1\frac{1}{2}$	$1\frac{1}{16}$	...	$\frac{13}{16}+\frac{1}{32}$	·76
$\frac{3}{8}$	$1\frac{3}{4}$	$1\frac{1}{4}$	...	1	1.10
$\frac{7}{16}$	2	$1\frac{7}{16}$	...	$1\frac{1}{8}+\frac{1}{32}$	1.50
$\frac{1}{2}$	$2\frac{3}{8}$	$1\frac{11}{16}$	$2\frac{3}{4}$	$1\frac{3}{8}$	1.96
$\frac{9}{16}$	$2\frac{11}{16}$	$1\frac{7}{8}$	3	$1\frac{1}{2}$	2.48
$\frac{5}{8}$	$2\frac{7}{8}$	$2\frac{1}{16}$	$3\frac{3}{16}$	$1\frac{5}{8}+\frac{1}{32}$	3·06
$\frac{11}{16}$	$3\frac{1}{4}$	$2\frac{1}{4}$	$3\frac{3}{4}$	$1\frac{13}{16}$	3·71
$\frac{3}{4}$	$3\frac{5}{8}$	$2\frac{1}{2}$	$4\frac{3}{16}$	2	4·41
$\frac{13}{16}$	$3\frac{3}{4}$	$2\frac{5}{8}$	$4\frac{1}{4}$	$2\frac{1}{8}$	5·18
$\frac{7}{8}$	$4\frac{1}{8}$	$2\frac{15}{16}$	$4\frac{11}{16}$	$2\frac{3}{8}$	6.01
$\frac{15}{16}$	$4\frac{3}{8}$	$3\frac{1}{8}$	$4\frac{7}{8}$	$2\frac{1}{2}$	6.90
1	$4\frac{1}{2}$	$3\frac{1}{4}$	5	$2\frac{5}{8}$	7·85
$1\frac{1}{16}$	$4\frac{11}{16}$	$3\frac{1}{2}$	$5\frac{7}{16}$	$2\frac{11}{16}$	8.86
$1\frac{1}{8}$	$5\frac{3}{16}$	$3\frac{11}{16}$	$5\frac{7}{8}$	$2\frac{15}{16}$	9·94
$1\frac{3}{16}$	$5\frac{11}{16}$	$3\frac{7}{8}$	$6\frac{3}{8}$	$3\frac{1}{8}$	11.07
$1\frac{1}{4}$	$5\frac{7}{16}$	4	$6\frac{13}{16}$	$3\frac{3}{16}$	12.27

When making cupped pulleys it is necessary to make the recesses to suit the chain with which they are to be worked. The reason is, that as the links are welded by hand, slight variations occur in the dimensions of chains normally alike.

The chains used on cranes vary from $\frac{1}{4}$ to $1\frac{1}{4}$ in. size of iron. But it is not always advisable to use the largest chain. It is frequently better to employ a smaller size, with a return or snatch block. The most useful sizes range from $\frac{7}{16}$, to $\frac{11}{16}$, or $\frac{3}{4}$ in. Above this, chains are very stiff and clumsy, and, special cases excepted, it is better to use wire rope when a direct quick lift is desired.

Chains need periodical inspection and annealing to pre-

vent or delay the setting up of crystallisation in the iron. These operations should be performed at least once a year in the case of cranes which are in constant use. The links are examined individually by inspection, and are tapped with a hammer to detect the presence of incipient cracks. If such are found present, the faulty link or links must be cut out. Annealing is done by heating the chains slowly in a clear fire, or in a furnace, free from contact with fuel, letting them remain at a red heat for a day, or a day and a night, and allowing them to cool down slowly. They are then reeved round a sheave pulley and protected with a coat of boiled linseed oil applied with a brush.

Chains are very liable to become atwist, which tends to produce strains under the action of a load. New chains are often twisted. It is removed by laying the chain out along on the ground, and turning it about until the twist is taken out. When a chain becomes twisted on its drum, the slack is run out, and the twist removed by turning it at the snatch block.

It is in every way better to use grooved drums for crane chains than smooth ones. In the latter the chains are liable to override, especially at high speeds, and then slipping off, surging, twisting, and overstraining takes place. Running in grooves, the chain is compelled to follow its proper course, besides which it is supported alternately on flats instead of being strained across the angles.

Pitch chain is used to transmit power for short distances. Its principal applications are for transmitting motion from the driving axle to another driver on the trucks of portable cranes, and operating the ground wheels of Goliath and gantry cranes from a shaft running alongside the gantry beams, and which is driven by the crab engines.

Pitch chains are used for transmitting movement to the wheel axles of travelling cranes and Goliaths, because the centres are too far apart to be covered by toothed gears, and shafts. The drive is positive, and there is no limit within

reason to which it is not applicable, since it ranges from 2 or 3 ft. to 30 or 40 ft. The chains fit over teeth of suitable form cast with their wheels.

Pitch chains are usually made by the crane-makers themselves in pairs of links only, instead of in thin laminæ, Fig. 162, which is the better plan. They are stamped in dies, and drilled in jigs, the pins are turned in a turret lathe,

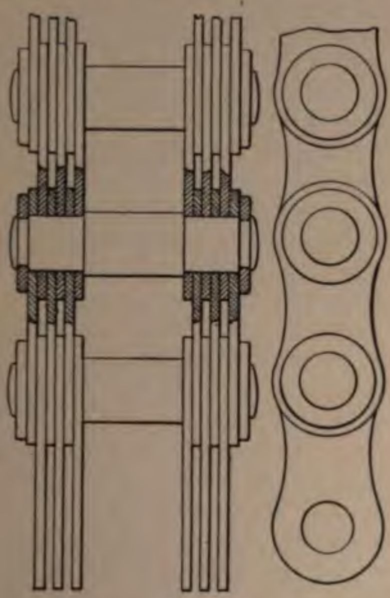


Fig. 162.

and the ends riveted over by hand. The small sizes of chains are still usually made with single-plated links, but large ones should have more than one, because greater safety is secured in this way than with a single thick link. These are stud chains always, and the links are riveted over at each end. The sprocket wheels are cast from patterns in iron, or in steel, and the links as a rule fit to the rough

castings. In high-class work, and for heavy transmission, the teeth of the wheels are properly tooled, either by slotting, or preferably milling.

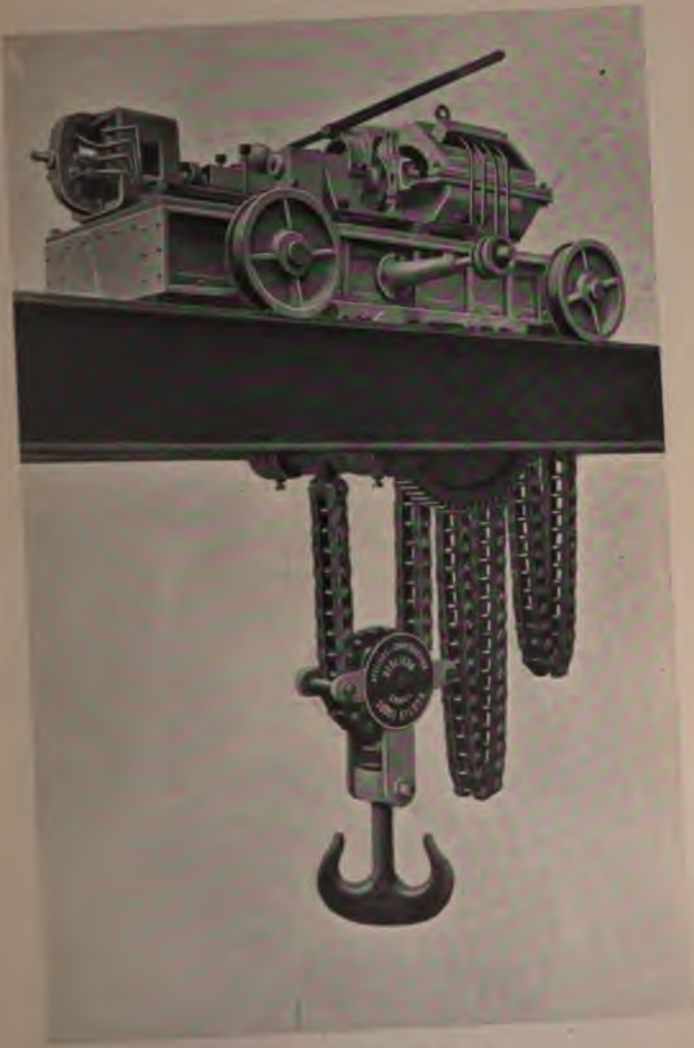
Pitch chains are used to a considerable extent on the Continent for hoisting, though they are scarcely used here. In place of the usual barrel, a sprocket winds up the chain, and the slack of this is run into a box as it is hoisted (see Plate).

Hempen ropes have been employed on cranes for more than a century. They are still used for light warehouse cranes, derricks, and winches, but are seldom employed for loads of more than from 10 or 15 cwt. But they are utilised as slings for hoisting weights much heavier.

Wire rope on the other hand, though its introduction dates back only about twenty years, is used alike for the heaviest, as for the lightest loads, and is in fact the best thing to employ on the biggest cranes, because, if for no other reason, that it occupies much less space than chain of equivalent strength. It is safer than chain, because it gives warning by stretching before fracture. But it requires larger drums in order to avoid risk of stretching of the outer strands when the ropes are being coiled round.

The kind of rope commonly used is a specially flexible one composed of six strands, each of twelve wires, enclosing a hempen core, and the whole being laid round a hempen heart. These are termed compound ropes. If a very high degree of flexibility is required, a larger number of wires of smaller size is used, the hemp cores being diminished in size, or omitted, excepting the centre one or heart. Ninety tons per square inch is the breaking strength of the wire, though a higher strength is obtainable if desired. The ropes which are made entirely of wire weigh of course more per fathom than those with hemp cores.

The minimum diameter of drum or sheave around which wire ropes should be wound is thirty times the circumference of the rope used. A wire rope occupies about



Thirty-ton Electric Crab.

(OERLIKON COMPANY, ZURICH.)

[To face p. 160.

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to a thimble, Fig. 163, both for attachment to the drum, and to the hook, see p. 177. In light cranes the thimble is sometimes omitted in the case of the drum fastening, and instead a tapered hole is cored in the lug, the plain end of the rope passed through it from the small end, and tightened at the large end by driving in a steel wedge.

An important difference in the hempen and the wire ropes is the length of the splice. From 6 to 9 ft. is long enough for the former, the latter varies from 30 to 60 ft. When a rope is closed in the opposite direction to that in which the strands are laid, 15 ft. is unlaid at each end to form the splice; when closed in the same direction, 30 ft. is unlaid at each end for splicing.

Cotton rope driving is still largely employed on overhead travellers, and on single rail cranes, notwithstanding that electric driving has been busily supplanting it. These ropes have in many instances given much trouble, due to several causes, so that their average life is much less than that of main driving ropes. The principal reasons are, that less care is usually taken in regard to having the pulleys large enough, smooth in the grooves, properly balanced, and in the avoidance of sharp bends.

Cotton, and manila, are preferred to hemp for crane ropes, because they are softer, more flexible, stronger, stretch less, and are more durable. Cotton is used with us, manila is extensively employed in America. Four strands are used in preference to three. Mr Hart's ropes are made of cotton alone, and each strand has a core which is not twisted, so that the tendency to stretch is as good as eliminated. Each central core is covered spirally with ten twisted cords of cotton yarn. Experience shows that equally good results are obtained with manila, or cotton ropes, if equal care is bestowed on the size and shape of the pulleys, and on lubrication.

In the manufacture of manila ropes the fibres are first spun into a yarn twisted in a right-hand direction. From

[redacted]

twenty to eighty of these yarns are then twisted together in the opposite direction, the number depending on the size of the rope. Four of these strands are then twisted together right hand to form the rope. The effect of strain on the rope is therefore to cause these opposite twists to neutralise one another, or nearly so.

It is because it is impossible to make these exactly neutralise each other that the twist has to be taken out of a new rope. A certain amount comes out in the course of the wear of the first day or two, and the rope stretches, but afterwards the length will remain nearly constant unless the rope is overloaded.

Ropes wear either externally, or internally. The first is due to the friction between the rope and its pulley, and the constant bending of the fibres round the curves of the pulleys. The second is due to the friction of the fibres over each other, as the rope is alternately bent and straightened, the result of which on opening a badly worn rope is seen in the form of powder. To reduce this, the yarns of good manila ropes are lubricated with plumbago and tallow, besides being rendered partly waterproof.

A frequent cause of failure in ropes has been too short a splice, or a splice not evenly made. A short splice of 2 or 3 ft. will inevitably be pulled out. The length should not be less than stated above. On its evenness or otherwise also its durability depends. It should not be larger or smaller than the rest of the rope.

3,300 ft. a minute is a good average speed for crane ropes. Ropes must not be overstrained; they are not worked in good practice beyond about one-twentieth of their breaking strain reckoned at the splice.

The diameters of pulleys for crane ropes should not be less than forty times the diameter of the rope.

CHAPTER XIII.

CHAIN PULLEYS, SPROCKET WHEELS, AND ROPE WHEELS.

Classes of Pulleys used on Cranes—Plain Wheels—Flanges—Cupped Wheels—Chain Wheels with Nibs—Sprocket Wheels—Rope Wheels—Wave Wheels—Guides.

PULLEYS on cranes are used for various purposes, as fixed pulleys for altering the direction of movement of chains or ropes, movable pulleys, as in snatch blocks, and in the pulley blocks. They are either plain, or cupped to receive the links of the chains. And they are simply revolved by the coercion of their chains or ropes, as in hoisting and lowering, or they exert a pull on the chain, as in cupped drums and sprocket wheels, which are used for the travelling and other gears of cranes.

The sectional forms of pulleys vary with these functions, and with the nature of the lifting agent employed, which is either short link chain, or round wire rope, or hempen rope.

Plain wheels for chains are those in which the section is continuous all round. A concave section is very common, but it is slightly open to objection, because the chain lies diagonally in the groove, and is subject to strain due to the side pressure on the links. But the chief practical objection is that the chain is liable to twist in its length, since there is nothing in the way of coercion exercised to keep it in line. In the heavier types of cranes, therefore, the sheave wheels generally have a grooved section similar to that on drums, Fig. 152, p. 150, in which the chains ride flatwise, and every alternate link falls freely into the groove. In slow-moving

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cranes, as on some of hydraulic type, flanges are sometimes omitted, as they are not really necessary in such cases. In no instance must flanges be allowed to come into contact with the edges of the chain links, but a side clearance of from $\frac{1}{8}$ to $\frac{1}{4}$ in. must be allowed. Without this clearance the chain will bear hard against the flanges, and burst portions of them off. For a rapidly moving chain liable to surging, the flanges are a safeguard, and should always be included. All pulleys of this class must be of large diameter, otherwise the links are unduly stressed, being strained over them.

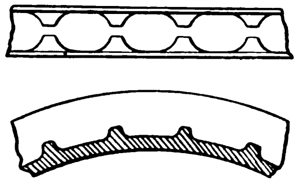

Fig. 164.

The cupped form of sheave, Fig. 164, is used when the chain has to be led by the sheave, or to lead it positively without slip. These wheels are troublesome to make correctly, and a perfect working fit is not easily retained because the chains stretch with use. Hence they are usually of small diameter, a matter of no moment in this case, as in the plain types instanced, because each alternate link lies

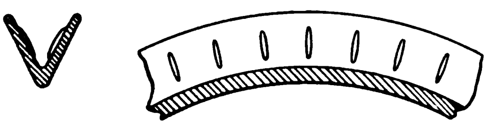

Fig. 165.

flat in its recess, and is not strained by any bending action as when running over a plain pulley.

Chain wheels with nibs are used for operating light hand travellers, both for travelling the girders, and the crab. They are of the section shown in Fig. 165, and the nibs are cast at intervals to afford a bite to the chain by which the wheel is pulled round. They are also used for actuating

the racking carriages of triangular-framed wall frames. They are efficient for their purpose, owing to the frictional contact afforded by the nibs round the large arc of contact,—half the circumference afforded by the pulley rim.

Sprocket wheels are a special type of chain wheel used for pitch chain, for transmitting motion to the travelling wheels of portable; and Goliath cranes. They are cast in iron, or in steel, and the pitch of the sprockets or teeth is the same as the pitch of the chain. The disadvantage of this is, that as the chains stretch with service they override on their teeth. In the Renold system of chains, which have been also fitted to cranes to some extent, this is prevented by adopting a different pitch for the wheels from that of the chain. But this refinement is not generally adopted by the crane-makers. Sprocket wheels are designed with the idea, that when a wheel and chain are in engagement all teeth are acting, and that no slipping can occur. But though a wheel and chain may be made to fit thus when new, yet as soon as work begins the chain lengthens, both in pitch, and in its pivot bearing, and thus after a little service it can never be in contact with more than one tooth at once. A result which follows is, that the driving wheel tends to run faster, and the driven wheel slower than the chain. Mr Renold designs wheels and chains with different pitches and tooth shapes to correct these errors, and uses cut wheels invariably, as cast ones are not accurate enough to give good results.

Fig. 166.

Rope wheels have come into very extensive use since the development of the wire rope industry. Previous to that, the rope wheels used were made for hempen, and cotton ropes, forms which have much in common.

Pulley grooves should always be turned, to prevent the fraying of the wires of which the rope is composed, and this applies to hempen as well as to wire ropes. A rough cast

rim wears out a rope very quickly, the most marked examples of which are furnished by the transmission pulleys of cotton rope travellers. In a correct section for a rope wheel, the point to observe is, that the rope bears only on the bottom of the groove. The side clearance prevents the unnecessary and injurious friction which would occur if the rope were in contact with the groove round its semi-diameter.

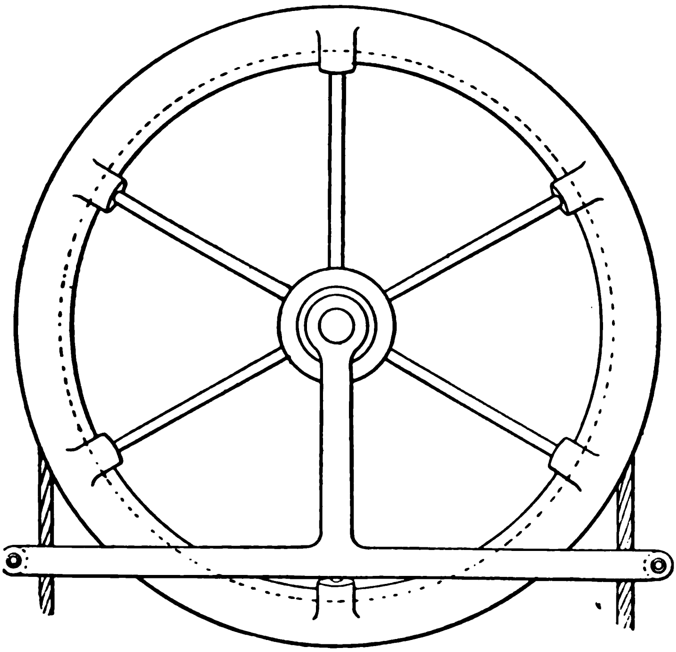

Fig. 167.

A peculiar form of rope wheel for hempen ropes has been used on many travellers, and called the wave wheel, Fig. 166, so-called because a waved or sinuous disposition is imparted to the lower part of the groove in which the rope lays. This is imparted in order to increase the bite of the rope, and is very efficient. The wheels are rather expensive,

and are not now used to a great extent, being chiefly employed for ropes to actuate the gears of light travellers, &c.

Figs. 167, 168 illustrate two forms of the rope wheel, the first with wrought-iron arms, the second with cast. Both types are used on overhead travelling cranes operated by hand, the ropes being dependent. The arms in Fig. 167 are strutted, that is they lie alternately in different planes,

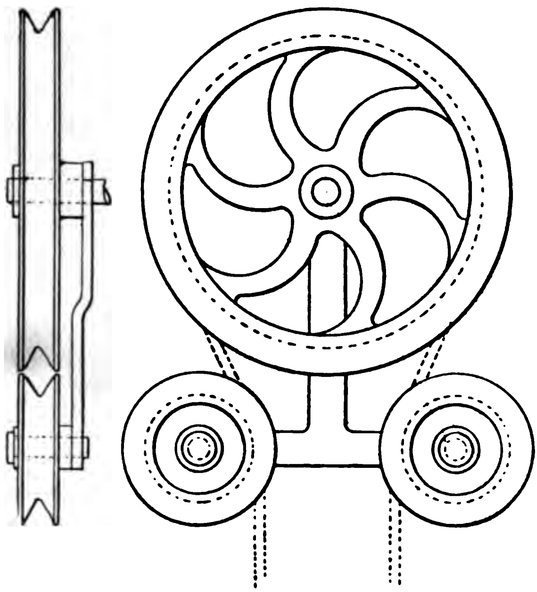

Fig. 168.

where they enter the boss into which they are cast. Fig. 168 shows the guide pulleys frequently used to bring the lower portions of the rope around a larger arc of contact with the pulley than is obtained in the case of the large pulley, Fig. 167. Tee-shaped guides are fitted in each case around the centre pin, to prevent the rope from getting off the pulleys.

CHAPTER XIV.

HOOKS, SNATCH BLOCKS, AND ANCHORAGES.

The Forms of Hooks—Snatch Blocks—Cast-iron Blocks—Built-up Blocks—Shackles—Ball Races—Anchorages of Chains.

THE hooks of cranes are single or double. They are attached directly to their chains, or with an intermediary swivel. They are mostly open. When the attachment at the termination of the chain is closed, it is termed a shackle. Hooks are used with or without snatch blocks. They are made usually of best wrought iron, bent round to retain the

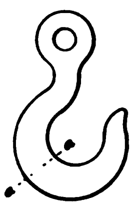

Fig. 169.

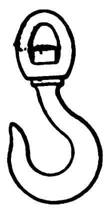

Fig. 170.

greatest strength of the fibre. In recent years hooks have been made of mild steel stamped in dies. A plain hook is shown in Fig. 169, with an eye only, for direct attachment to its chain or rope. A swivel hook is seen in Fig. 170. The weakest section of a hook lies along the plane *a*—*a*, Fig. 169, due to the leverage of the load. The largest section of metal is therefore massed there. The sections across the eye are only subject to a direct pull. In Fig.

171, which is a sling chain, the method of attachment of the form of hook in Fig. 169 is seen. In Fig. 172 the swivel attachment of the hook in Fig. 170 is shown, together with a counterbalance ball weight by which the slack of the chain is overhauled when there is no load being lifted. The hook in Fig. 169 is never used for any but light and moderate loads, that in Fig. 170 is suitable for all loads.

The snatch, or return block is used on all cranes excepting those of low powers, in order to increase the lifting

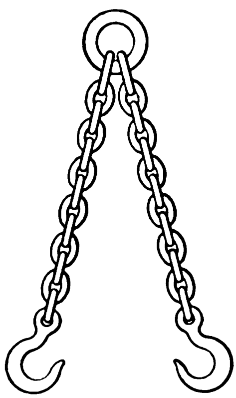

Fig. 171.

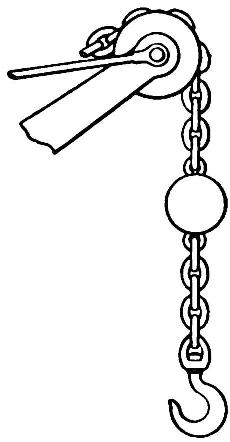

Fig. 172.

power without unduly increasing the size of the chain, or wire rope which sustains the weight of the load. The designs of these blocks vary to a wide extent. Essentially they comprise cheeks, a pulley or pulleys, and a swivelling hook.

Cast-iron snatch blocks are used sometimes for small cranes, being cheaper than those built up of plate and forgings. One of these is shown in Fig. 173; the cheeks are formed of two castings flanged inwardly and planed in the joints. They are fastened with bolts. The metal is

thickened to form bosses for the pulley pin. The hole for the hook is so bored that no countersinking or riveting is necessary, but the hook is turned to fit the enlarged hemispherical seating for it, in which it swivels. The hole is

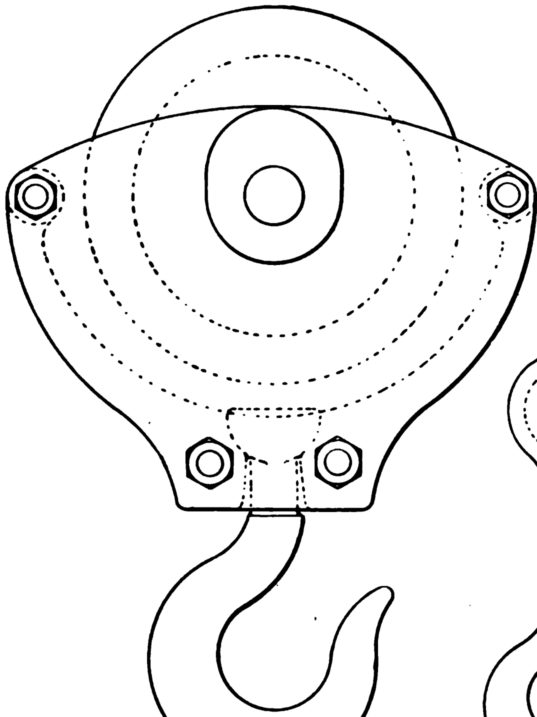

Fig. 173.

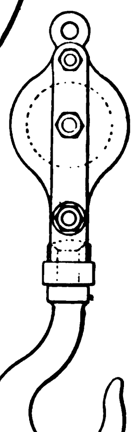

Fig. 174.

slightly bell-mouthed at the bottom, to allow the hook freedom of movement in the horizontal plane.

Fig. 174 shows a snatch block formed of two side plates of sheet iron or steel, stiffened with side bars, which take

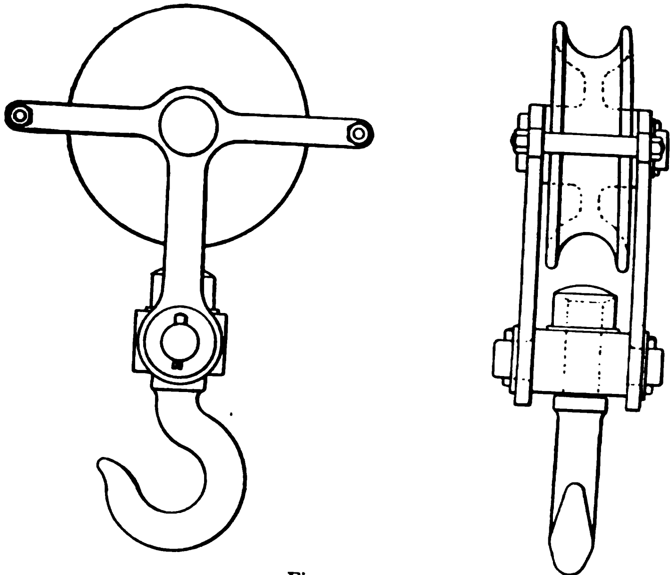

Fig. 175.

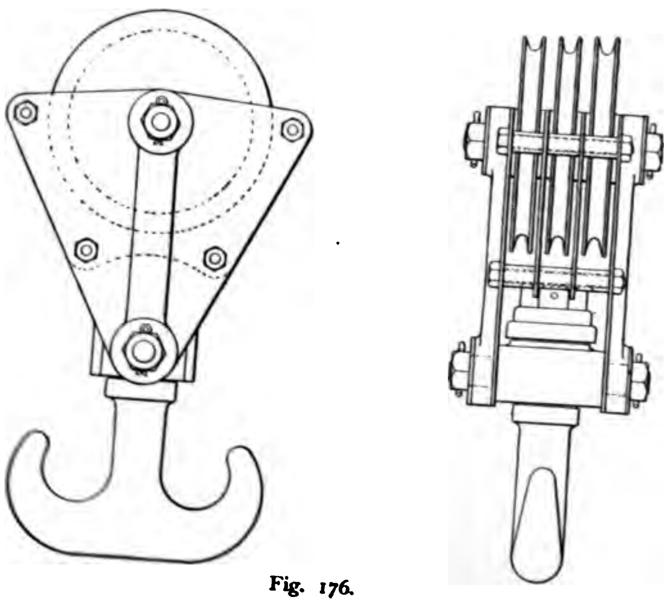

Fig. 176.

the load, and kept apart with distance pieces. The hook swivels in a block through which its neck passes, and in which it is secured by riveting over. In Fig. 175 the cheeks take the form of two forged crosses maintained apart by distance pieces. The hook swivels as in the previous case, in a block of steel which also forms a distance piece. Fig. 176 is a heavy type of block with three pulleys for wire rope. Here the method of construction is with forgings, which take the pulley pin, and the necks of the swivel block, and steel plates stiffen the whole arrangement. Intermediate plates separate the pulleys, being maintained at their proper distances apart by short distance pieces of tube. In this example the hook is double—the ram's horn—a frequent type adopted in very heavy cranes, permitting of the use of two chains better than the common type does.

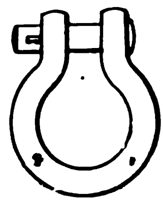

Fig. 177.

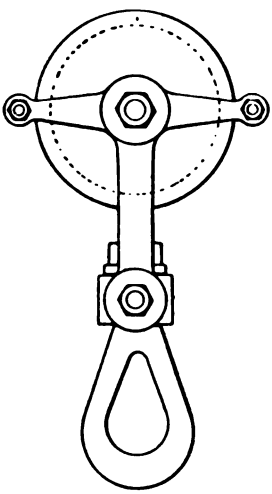

Fig. 178.

Fig. 177 shows a light form of shackle separately from its attachment, and Fig. 178 one of heavier type, fitted to swivel in its snatch block. These are generally used for very heavy loads. Frequently a shackle like Fig. 177 is inserted in one like Fig. 178, and the lifting chain is carried on the former. There is then no risk of the chain slipping out as there sometimes is in the case of an open side hook. These take the place of a safety hook, that is, one in which the open side is closed by a spring contrivance after the insertion of the load, to pre-

vent its pulling off the hook, which is very possible in some cases, where the road may tilt, or touch ground. Shackles like Fig. 177 are used for the attachment of the return chain at the crane end, as at the top of the jib.

At the present time large numbers of cranes have their crane hooks made to swivel on ball races. It used to be a terrible task to slew the hook of a heavy crane when loaded. Oil was applied to the neck, and men pulled round at the load. A device also used on heavy cranes is worm gear, the worm being turned by a ratchet handle, so actuating the worm wheel on the axis of the hook. Then several hardened washers were used to lessen the friction, following that, conical roller races, borrowed from the turntables. A good number of these have been fitted, and are doubtless the best for the very heaviest loads. These rollers and races are

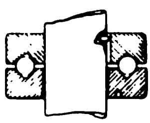

Fig. 179.

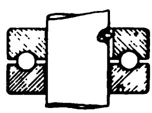

Fig. 180.

turned in cast steel, but no attempt is made to harden them. Recently ball bearing makers have turned their attention to these fittings, and supply hardened and ground roller races for crane hooks. Owing to the imperfect methods which were adopted in making the early roller races, they were far from satisfactory, and so ball races were introduced. Many of these have been made incorrectly, with the sloping sides of the races of equal length and angle, which causes the balls to slide partly, instead of rolling simply. The correct method is shown in Fig. 179, in which the points of contact lie along lines drawn radially from the centre. These points are in the same relation then as in conical rollers. Another shape which is much fitted to races is that shown in Fig. 180, in which instead of four bearing points, two only are provided, at the bottoms of concave

grooves. In the Hoffman ball race a self-adjusting device exists in the fitting of a floating ring which slips on a conical seating in the ball case. As the hook therefore sways a few degrees out of the perpendicular, the close

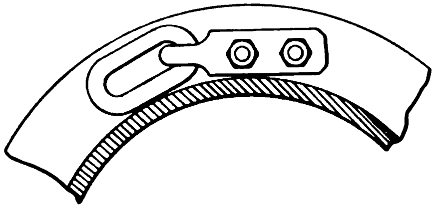

Fig. 181.

contact of the balls between their seatings is maintained intact and perfect. Besides this, a retaining ring or wire prevents all risk of the balls jumping out of place when the bearing is taken out.

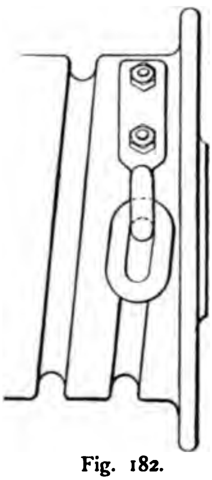

Fig. 182.

The end of the chain next the barrel or hoisting drum is attached in such a way as to remain permanently fastened. This may be done in several ways. One is to bolt an eye link or shutting link to one of the flanges, Fig. 181, or to

the body of the drum, Figs. 182, 183. But this is not so neat a method as some others. Another and common way is

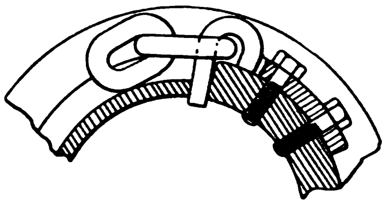

Fig. 183.

to cast a lug on the drum, Fig. 184, and pass an eye bolt through it. This is a good plan. Another is to core a hole

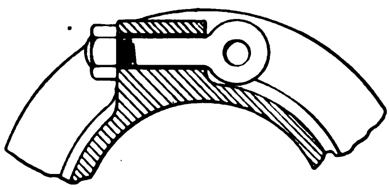

Fig. 184.

in the barrel to receive the end of an eye link, and fasten it with a screw, Fig. 185, passed through from the outside.

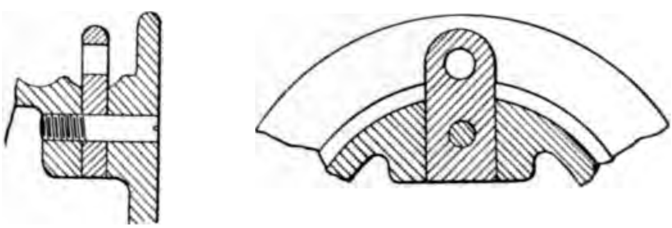

Fig. 185.

This also is a good method. In the case of wire ropes, a method sometimes adopted, though not a good one, is to

cast a lug with a taper hole, insert the end of the rope from the smaller end, and wedge it out at the other, Fig. 186.

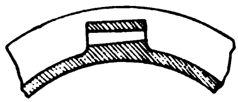

Fig. 186.

The best method is that shown in Fig. 187, where the wire rope is brought through an opening cast in the drum, and its eye, with a thimble inserted, is passed between lugs cast

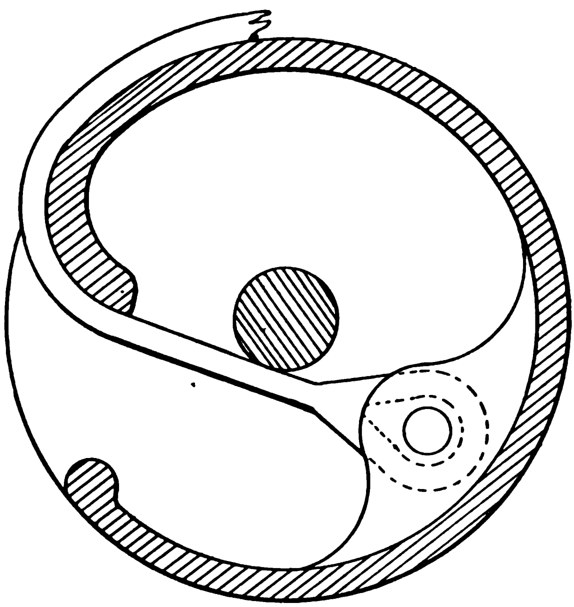

Fig. 187.

internally, and there secured with a pin passed in from the end of the drum.

SECTION II.

THE METHODS OF OPERATION OF CRANES.

CHAPTER XV.

HAND, STEAM, WATER, AIR, AND ELECTRICITY.

Radius of Winch Handles—Height from Platform—Rope and Chain Wheels—Steam Power—Class of Engines used and Boilers—Water Power—Its Utilities and Limitations—Air—Types of Air Hoists—Electricity—Its Value—Reversals of Motion—Early and Later Motors—Advantages of Electric Drive.

THE methods of operation of cranes include Hand Power, Steam, Water, Air, and Electricity. With some few exceptions these are in rivalry, in the same classes of cranes. That is, in certain types of cranes, examples occur in which each agency is employed, in other types four come into competition, in others three, or only two.

HAND POWER.

This is the oldest method of operating cranes, and one which retains its hold very tenaciously. There will always be room for hand cranes of nearly all types, but in many cases they might, when retained, be superseded with advantage in regard to speed, and with much economy also. The proper sphere for a hand crane is when the work done is

very intermittent, when long intervals of idleness elapse between spells of service, and generally when but moderate loads have to be lifted.

At one time all cranes were operated by hand, then came hydraulic, and steam power, afterwards air, and finally electricity. Hand power is nevertheless of great value still in very many instances.

The simplest application of the latter is through winch handles. These are usually of 16 or 17 in. radius, and the power of a man exerted at that radius is multiplied into the circumference of the circle described by the handle. The power which a man is able to exercise is very variable, depending on the time through which it is maintained. Fifteen pounds is usually taken in calculations as being an average continued through a day's work. Some estimate on a basis of 20 lbs. For short periods from 25 to 30 lbs. can be taken.

The height of the handles is generally fixed at about 3 ft. from the ground line, or from the platform on which the man stands, as it is found that he is best able to exercise his maximum energy with the handles at about that height. Bringing them higher or lower involves reaching too high or too low, at the extremes of height or depth during the revolutions of the handles.

Winch handles are fitted to warehouse, and wharf cranes, to fixed, and portable cranes, and to overhead travellers.

Another method of operation by hand is through rope, or chain wheels. The application of these lies in overhead travellers, and in the jennys of triangular-framed cranes, where the man operates from the ground. The rope or chain comes down to within easy reach, and pulling at it turns the wheel above, and with it the gearing. The mechanical gain obtained is the same as that of the winch handles. The wheels used have plain rims, or they are waved, or have nibs cast on to increase the bite of the rope or chain, see Chapter XIII., p. 165.

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Steam Power.

This has filled a wider place in crane driving in the past than it is likely to do again. Like hand power, it cannot be wholly superseded for many years to come, if ever, but its sphere will be narrowed. Steam is used for driving every type of crane made, from the lightest to the most powerful. It is so easy to put an engine on any crane, and it matters little how roughly made it may be. A boiler too is an excellent counterbalance to a jib.

It is the practice in crane-making firms to have a few standard types of engines and boilers, and make these do duty for nearly the whole range of steam cranes of all classes, relying on the gearing to make up the power wanted at the hook. Such engines and boilers are of simple type. The cylinders are bolted to side frames, or to foot plates, or beds, according to the class of crane, or crab, the steam works expansively with a single valve set with a lap, giving admission during about three-quarters, or five-eighths of the stroke, and the steam exhausts into the atmosphere direct. The nature of the service is not such as to admit of any of the usual economies that are practised with high-class stationary engines. The service is very hard, an enormous quantity of steam being required during the performance of maximum duty, besides which the service is usually of a more or less intermittent character. During intervals of loading it is usually necessary to fire hard, in order to get up the pressure that has run down quickly while lifting.

The boiler employed is, with very few exceptions, of the common vertical type, as being easily fired, and kept in working order. The number of cross tubes, and the various details, depend on the dimensions. The tubes number from one to three, in the smallest, and largest boilers respectively. The crowns are stayed, fire bars are cast, or wrought, and generally the shell is lagged with wood, or sheet iron, to lessen the radiation, and waste of heat. Besides these a

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good many verticals are used which have patented arrangements of fire tubes, the specialities of firms. Horizontal locomotive type boilers have been used to a limited extent on some large cranes.

WATER POWER.

Water is used for fixed cranes chiefly, though systems of jointed or walking pipes provide means for its conveyance through a range of a few feet to some special types of portable cranes, chiefly those which are used for riveting. Many of the great fixed cranes on our quays and dock walls are of hydraulic type, and so are many of a much lighter class in warehouses and shops. This is an admirable source of power for cranes of fixed type.

The movement of a hydraulic crane is smoother than that of a steam-driven one, and is more perfectly under control. It is, however, more complicated, and massive, load for load, the cylinders and chains occupying a good deal of room, and the base is of large proportions. The hydraulic crane is however, preferable to steam for fixed wharf duty, and for warehouses. It is a fair rival to steam for heavy work on dock sides. For carrying hydraulic riveting machines along over their work it is the best agency at present. An objection to water power is frost, but this is guarded against in cold climates by bringing the pipes underground, and by admixture of glycerine with the power water. The latter is also let out of the pipes and cylinders at night. The relative pressure of water is a question of area of rams or pistons. The length of stroke is either direct, or altered by chains or pulleys.

AIR.

The power of compressed air has only been successfully applied to the hoisting of loads during a comparatively recent period, and the greatest development of this agency has occurred in America. It is not employed for very heavy

cranes, but for the lighter ones only, and the hoist is usually direct, that is, the maximum height of lift is the same as the full length of stroke of the piston in the air cylinder.

The usual form of air hoist comprises an air cylinder of a few inches in diameter, and a close-fitting piston and rod, from the lower end of which the load hangs. The great objection to this type of machine long was, and still is, in certain cases, that the elasticity and compressibility of the air induces a jerky motion in the piston, which is fatal to precise and safe lifting. This no longer holds good in the best hoists, which are governed in various fashions. The result is that the light hoists capable of lifting loads of a few hundredweights are used by thousands in American foundries, and machine shops, in warehouses and stores. A system of pipes conveys compressed air throughout the area to be served, and the hoists are connected thereto at intervals with flexible pipe.

Besides the single vertical cylinder type of hoist, there are the horizontal, and inclined cylinder types used in crane framework, and those which are suspended by gimbal joints from traveller beams along which they are traversed.

There are a few lesser used types of air-operated cranes, in which small three-cylinder engines produce a rotary motion, and are fitted to travellers, in the same fashion as electric motors.

Electricity.

The general application of the electric current dates from about 1890, though isolated examples might have been found at an earlier period. It is rather astonishing how this has grown since. The electric traveller has been affected by the innovation more than any other single type, the gantry type of wharf crane following that.

The electric drive owes its value to the fact that a simple wire conductor bridges over any interval that separates the crane from its source of energy. Instead of generating energy on the crane, as in the steam-driven type, it is

brought from a dynamo elsewhere, and reconverted into motion by a motor or motors on the crane. Dead weight is thereby lessened, great distances offer no difficulties, and pipes are abolished. No steam, or objectionable fumes, are produced. It is therefore on the overhead travelling types of cranes that the electric drive achieved its first and its greatest triumph.

But the first difficulty encountered was due to the fact that all cranes have to be reversed at frequent intervals for the two movements of hoisting and lowering, travelling and traversing. All crane engines are made for reversal, and where the actuating agent runs constantly in one direction as does the cotton rope, the intricate mechanism of clutches and sets of gears, or of open and crossed belts, comes in. When the first motors were put on cranes all this mechanism was necessarily retained, because the motors ran only in one direction. Not until some years after were reversible motors fitted, but now they are generally employed, with the result that much complicated machinery is dispensed with, lightening the crane and vastly increasing its efficiency.

Another point is, that the early motors were all very high speeded, much higher than any of the movements of any crane, and so a considerable amount of reducing gear became necessary, which increased the friction, and frictional losses. Then slower speeded motors of large dimensions were introduced, and the gears reduced, at which stage the modern electric crane has arrived at the present time. The early open motors have practically universally given place to the enclosed type, which may be surrounded by a large amount of dust and dirt without injury.

The advantages of the electric drive are so great that every year now adds enormously to the numbers of new cranes so operated. In the old overhead travelling cranes, whether driven by square shafts, or ropes, the shafts and ropes were running constantly, though the work of the crane might be very intermittent. But in an electric crane none

of the mechanism is running until the attendant switches on the current.

Further, the same amount of power is transmitted in the older overhead cranes for operating all the various motions, though there is a wide difference in the power used in hoisting, travelling, and traversing. In a modern electric travelling crane each of these movements is operated by its own motor of a power adapted to its work. In a good many cranes also an auxiliary hoist is included for dealing rapidly with very light loads, and this also has its own motor.

An advantage of the application of the electric current to light hoists is that their speeds can be increased very greatly over those of the hand operated differential type, yet without sacrificing safety, because the hoist, through the magnetic brake, is self-sustaining.

The employment of the new agents, air, and electricity, marks a very great advance in crane design, which is paralleled only by the introduction of steam, and of water in the past. It would be easy to dwell at length on this forecast, but space forbids.

SECTION III.

THE MATERIALS USED IN CRANES, AND THEIR SPECIFIC APPLICATION.

CHAPTER XVI.

TIMBER, CAST IRON, WROUGHT IRON, STEEL, GUN-METAL, PHOSPHOR BRONZE, AND DELTA METAL.

Timber — Kinds used, and Specific Applications — Cast Iron — Its Utility—In Trucks—Cheeks—Cross Girders—Wrought Iron and Steel—In Trucks—Cheeks—Tension Roads—Gun-metal, &c.—In Bearings, Gears, &c.

THE materials used in cranes are not always similar even for cranes of similar types and dimensions. The following remarks will, however, cover most of the conditions which exist in general practice.

TIMBER.

Timber is not used to nearly so great an extent in crane work as of old. Yet a considerable amount enters into the construction of hand cranes, hand travellers, Goliaths, and derricks. It is put into trucks, cradles, the uprights of Goliaths, and gantries, and the jibs of cranes. It is a good and reliable material, lasting sound from a

quarter to half a century, with reasonable protection. The kinds used are red deal, pitch pine, and oak, all excellent materials when sound. Pitch pine is of especial value, because it can be obtained in long balks from 10 to 16 in. square, dimensions which are often required for overhead travellers, for Goliath framings, and for crane jibs. Oak is used chiefly in smaller sections of jibs, for which, if sound and well seasoned, it is an ideal material. Timber is used freely for the entire framings of derrick cranes, of triangular-framed cranes, for foundry and warehouse service.

Cast Iron.

Cast iron is employed more largely than any other single material in the general work of crane structures. The exceptions occur in some cranes of very special design, as those for service on permanent way, in breakdown work, in those used in powder factories, where gun-metal is exclusively employed, and in the big cranes where the plated work vastly predominates over the cast.

In cranes, as in all other departments of engineering, the facility which cast metal offers over forged or plated for the average run of work gives it pre eminence. It has, however, to be used with judgment, because of its weaknesses when in tension, or in transverse stress. It is seldom employed in simple tension, but when suitably designed it will stand severe cross breaking strains and shocks.

Trucks are made of timber, cast iron, wrought iron, and steel. Neither timber nor cast iron are much used now for the trucks of large cranes. When heavy loads have to be lifted, the surging and shock which frequently occur render the material liable to fracture, especially when the experience of a firm in the designing and proportioning of cast-iron trucks has not been very extensive. Very slight alterations in proportions will frequently make the difference between safety and insecurity. The strength of trucks is therefore

not so much a matter of calculation, as of experience, and trial and failure. The weakest part of a truck casting is generally at the junction of the central boss with the ribs, and this is just the part where the massing of metal is injudicious. But with careful designing, and moulding, trucks made wholly of cast iron can be usually depended on in cranes up to about 5 tons power. Above that it is better to frame the trucks of steel, enclosing a central casting which forms a step for the post, and path for the rollers. In that case the bearings for the axles must be bolted to the framing. But that is often done for convenience when the truck is made wholly of cast iron.

Cast iron is used to a considerable extent for the cheeks and side frames, the cross stretchers, or girders, which maintain the frames rigidly at their proper distance apart, and that form bearings and points of attachment for various fittings seldom made of any other material than cast iron. They are stiff and strong, and seldom fracture unless indeed by the overturning of a crane.

Wrought Iron and Steel.

Wrought iron, excepting for forgings, is used but little now in crane-making. It has been nearly supplanted in the work of the plater and boilermaker by mild steel, partly because the latter,—strength for strength—permits of the use of lighter scantlings, partly because steel has no grain, as wrought iron has, and the strength is therefore equal, irrespective of the direction in which plates are cut.

Trucks are not often now built up in iron because this material has been nearly displaced by steel for plated work. Generally they are built of plate and angle, but sometimes of H sections or of channels. The corners are united with angles. The centre casting prevents diagonal movement. Brackets are bolted to truck and centre casting to carry axles, or other attachments. Illustrations of trucks occur on pp. 81-85.

Though cast iron is employed for the side frame cheeks to a large extent, plated frames of wrought iro steel are filling a large place of late years. Generally tl occur in cranes of large power, in cranes for permai way, and in those in which it is desired to eliminate possible risks of fracture, incidental to the use of cast i The cost is greater, because the bearings for the shafts h to be fitted and bolted against the plate and angle, of wh the frames are built up, and the cost of plating is hea than that of moulding. But the advantages of the pl frames are so much superior to those of cast-iron ones, the use of the former has extended rapidly of late years, only in the case of large cranes, but also, though in a le degree, for those of low powers.

Iron and steel bars and rods are used for the shafts axles, and forged work. Often the engine shaft, and tr axles are of steel, and the remainder of iron. Tension r are mostly made in iron, when eyes have to be welded the ends. Common chains are of iron, pitch chains of st wire ropes of steel, though formerly these were of iron.

Castings of steel are now employed very extensively girders and brackets as well as for gears and wheels. T are lighter than those of iron, and more durable. Gener different patterns have to be made for steel because of difference in shrinkage, and apart from this they must so made if the advantage of lightness for equal strength i be secured.

GUN-METAL, PHOSPHOR BRONZE, AND DELTA METAL, &

Gun-metal and its alloys are used for bearings and m sliding surfaces, for small toothed wheels, for which ser raw-hide gears have come into competition with th Brass has practically no place in crane work. In g cranes, shafts and axles run in gun-metal bearings, mo divided, but some are solid. Only in cheap cranes do

shaft journals run in iron bearings. Worms are mostly made in phosphor bronze. These gear well with steel, whether lubricated or not, but steel worms will not run nicely with steel wheels, without risk of seizing. Delta metal is used for the shafts of light cranes, as well as for light gears. Raw hide is mostly employed in electrical reduction gears.

SECTION IV.

THE VARIOUS TYPES OF CRANES.

DIVISION I.—HAND CRANES.

CHAPTER XVII.

FIXED CRANES.

Pulley Blocks—Crabs—Triangular-framed Cranes—Whip Cranes—Wall Cranes—Wharf Cranes—Derricks—Goliaths—Sheer Legs—Lifts.

PULLEY BLOCKS.

THESE are used to a considerable extent in situations where a crane is not available. They are essential in heavy crabs and cranes, in the forms of snatch blocks. The power of a crab can be largely increased by the use of pulley blocks in conjunction therewith. In this way a very light crab can be made to lift 3 or 4 tons.

CRABS.

The value of these consists in their portability, and the wide range of power in which they are obtainable, which renders them of especial value for general outdoor service for builders, contractors, engineers, and miscellaneous use. A rope or chain can be led off from a crab, and brought over a monkey wheel direct to the hook, or through a return block. Or sets of pulley blocks can be used in cases where very great power is required. The rate of lift is very slow

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in hand crabs, but this is of less importance for occasional and temporary service than for constant duty.

Hand crabs are generally single, and double geared; only in exceptional cases are they treble-geared. The brake is fitted on the barrel shaft, sometimes on a rim cast on the barrel wheel, sometimes on an extension of the shaft outside the frames.

Variations in construction are, cheeks of cast iron, or steel plated, shaft holes bored in iron, or brass bushed. Bearings are seldom divided in the small crabs, but bosses of cast iron are bored in the solid. When cheeks are steel plated, the bosses are bolted to the plates, and should be also checked into holes bored in the plates, to ensure steadiness. A ratchet prevents the running down of the load, and a pawl keeps the pinion shaft in, or out of gear with the barrel wheel.

Triangular-framed Cranes.

These are the commonest, and the oldest types of cranes, Fig. 188. Made originally of timber, and still so constructed in numerous cases, the general pattern has been perpetuated in wrought iron and steel. They are used in foundries, and in other shops, and out of doors in stone yards, and quarries. They are frequently termed foundry cranes, from their common application to that particular service,—their handiness consisting in their command of a large and variable radius. The post A slews through a half circle, or through a complete circle, depending on its location, and the racking carriage B which runs along the top horizontal member gives a variable radius. Such cranes are made from a ton up to 10 or 15 tons power, are very durable and strong, but are of necessity very slow in their movements, for which reason they have been largely superseded in modern shops.

The post pivots at top and bottom. The hoisting gears C are single, or double, and in the highest powers treble; ratchet, and brake are fitted. The shafts are carried in cast-

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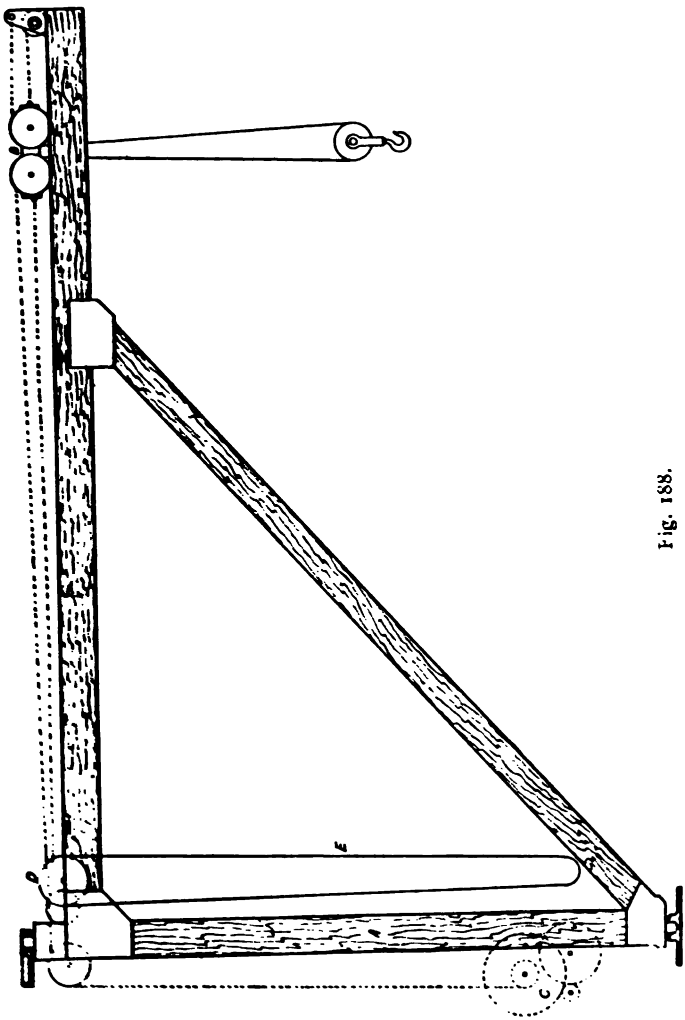

Fig. 188.

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iron cheeks bolted to the timber uprights at a suitable height from the ground for operating the handles. The carriage is racked along by a spider wheel D, and dependent chain or rope E. Red deal, pitch pine, or oak are the timbers used, the latter being the best, when of good quality, and well seasoned.

An increasing number of jibs are made of steel, and fewer of timber. The cost of steel is not greatly in excess of that of a timber jib, while it is more durable. Steel too is displacing iron rapidly, or it would be more correct to say, has displaced iron in this, as in other work. Great variety exists in the designs of jibs made of these materials. For the most part they are of the lattice type, but small ones are often made with solid-plated webs. Channels or H irons are generally used for the sides of the jibs for small cranes of this class, but large jibs are generally built up of plate and angle. In most cases jibs are made straight lengthwise, but many cases arise in which a bent jib is desirable, and then the scantlings have to be increased at the bent area, to compensate for the weakening due to curving, with increase of work involved. Some of the jibs are troublesome to make, being of a boxed or rectangular cross section, with diagonal bracings on each side.

WHIP CRANES.

These are light cranes for warehouse use, which derive their name from the practice of pulling at the rope that passes round the large pulley at the jib head, when light loads below 4 or 5 cwts. have to be lifted. When heavier loads are to be lifted, the winch handle is put on the barrel shaft for medium loads, and on the pinion shaft for the heaviest, which do not range beyond 2 or 3 tons in this type of crane. A rope is used on the big rope wheel that is on the same shaft as the barrel at the top of the post, which carries the chain. The lift is single only, and a ball is used for overhauling the weight of the chain.

Whip cranes are of two kinds. In one the post is pivoted at top and bottom, as in foundry and forge cranes. In the other it is independent, being stepped into a broad base which is bolted to the floor. A hollow casing encircles, and slews round the post, and carries the jib, and tie rods round a complete circle. A hand brake is fitted to the rope barrel.

The main parts of the pivoted type of crane are steel plated, those of the independent type are of cast iron. The base is a casting, the post, stepped into it, is. of steel, or wrought iron. The outer hollow casing which slews round the post is cast, and carries the bearings for the bottom drum, and the pinion shaft, and for the top or chain drum. The jib is of steel plate.

Wall Cranes.

These are triangular-framed jib cranes of the simplest kind, in which the post is pivoted in steps bolted to the wall of a warehouse, commanding a semicircular floor area. There are two types.

The simplest kind is built of wrought iron or steel bar, of about 2 in. diameter, alike in post, tie, and jib. The tie bar is nearly horizontal, the jib is curved, and stiffness is afforded to post and jib by tying all three members together with bars suitably bent to occupy the included space, and riveted to the members, and to each other. The chain is single, and is operated from a crab on a floor within the building against the wall of which the crane is pivoted. Such cranes are not suitable for loads exceeding a ton or 30 cwt.

In the second, the jib is horizontal, usually formed of two channel sections, and the ties come down at an angle. A racking carriage runs along the top of the jib, and is actuated by a dependent rope or chain from a spider wheel at the end next the post. The load is lifted by gearing

carried in a wall bracket; which is single, and double; and fitted with brake, and ratchet. Such cranes are adapted for loads up to about 3 tons, and are used in engineers' shops, for handling castings, foundry boxes, forged work, &c.

WHARF CRANES.

There is a class of fixed jib cranes which have no other name than that which designates the nature of their service, fixed wharf cranes, or sometimes fixed hand cranes. But by the term wharf crane, a broad type only is understood, which requires precise qualification for individual examples, since the design is modified in various ways.

The simplest and cheapest wharf cranes operated by hand comprise a long post of cast or wrought iron, let into a footstep, several feet below the ground line. The jib is stepped into a casting which encircles the post a few inches above the ground line, and that carries the rollers, and which is connected with rods to a casting that caps the post, in which casting the tie rods which come from the head of the jib are anchored. The hoisting gears are carried in cheeks bolted to the lower portion of the jib, and the slewing gear is at the rear of the encircling footstep casting.

Such cranes are made in large numbers for quarry work, railway goods sidings, and on wharves. They range in power from 1 to 10 tons. The jibs are either of timber, or of channel sections, and are generally, though not always in the smaller sizes, in two parts, maintained apart by distance pieces. The loads are carried by single chains, or by snatch blocks, and gears are single or double. Brakes, and ratchets are fitted.

A more advanced type of wharf crane has the same deep post, step, and plate, but cast-iron side frames bolted to a roller frame at the bottom, and to a distance piece which forms the top cap, fitting on the post, sustaining the weight of the superstructure. The jib is stepped into the bottom

roller frame casting, and the tie rods are attached either to the top cap, or to the side frames. The superstructure is slewed round by hand, or by means of a curb ring; in which case the pillar for the slewing gear is attached to the rear of the bottom, or roller frame. Single, and double gear is fitted up to 10 tons or 15 tons, but hand cranes of this type are made up to 30 tons with treble gear. In the larger cranes, cast-iron frames are often dispensed with in favour of wrought iron, or steel. And in the very small ones, simple channel sections sometimes supersede cast iron.

Derricks.

These cranes are certainly a century old in their cruder forms, but the best types are comparatively modern. They are used in all classes of outdoor work, on account of their wide range of operations, slewing round three parts of a circle, and in a large range of radius.

A hand derrick comprises mast, jib, and ties, which are rendered stable by sleepers secured to the ground, from the rear ends of which rigid raking tie rods proceed to the top of the post, carrying the bearing for the top pivot. The gears are fixed near the bottom of the mast, and are single or double, for hoisting. Another set of gears carried in the same cheeks actuates the derricking or radial movement of the jib. Both lifting and derricking chains pass over pulleys at the top of the mast, whence the lifting chain passes to the pulley at the top of the jib, and the derricking chain to a pulley at the rear of the rods. The two movements can be actuated separately, or in unison by suitable gears. So that while a load is being lifted or lowered, the radius can be increasing or lessening.

A peculiarity of the derrick is the fusee barrel, by which a load is maintained at a constant level while the radius of the jib is changing. As the radius lessens, and the jib rises, the chain winds towards the larger end of the barrel;

as the jib lowers, it winds towards the smaller part of the fusee barrel.

The stability of a derrick crane depends on the length of the sleepers, on the way in which they are secured at the rear, and on the strength and security of the back ties. The security of the jib depends on its own strength to resist thrust, and on the strength of its ties and chains, and their attachments, which is assisted slightly by the lifting chain.

Derricks are commonly timber framed throughout. Steel sections are frequently substituted for the larger cranes, and for foreign orders, but the same outlines are maintained as in timber, and the same details also of mechanism.

Goliaths.

A description of Goliaths will be found at p. 236, in the account of Travelling Cranes, and at p. 112. As the only difference in these and in the Fixed Goliaths consists in the presence or absence of the travelling gears, reference may be made to that account for the main construction. In the fixed type the uprights are fastened down on sleepers. They have but a limited use, in small yards, or to cover small areas of yards where there is variation in the localities where lifting has to be done.

Sheer Legs.

These are made in various forms. The commonest are temporary, and comprise three timbers united at the top by a bolt, and resting securely on the ground with spikes. A gin block, or a set of pulley blocks are suspended from the apex. In a more advanced type the timbers are stepped into cast-iron shoes, sunk, and fixed permanently into the ground, and united at the top with a cast-iron cap, from which pulley blocks depend, and which are actuated by a common double purchase crab fixed to the ground.

In a variation from this, the legs are not arranged equi-

distantly, but two are brought sufficiently near to receive a pair of cheeks by which the lifting gears are carried, without the employment of an intervening crab. The legs do not then meet in an apex, but a beam connects the pair adjacent with the single one, and the top pair of pulleys have their pin in this beam. Also, steel sections are substituted for timber in many sheer legs.

Sheer legs of these types range in power from 1 ton to about 15 tons. They are used for many purposes. One of the commonest is in locomotive and wagon sheds, for lifting the bodies, to permit of the examination of wheels, axles, and boxes, and the changing of wheels and axles. Others are used in dockyards, hand operated.

LIFTS.

The small hand-power lifts used in warehouses, public buildings, hotels, banks, restaurants, and such like, are of a very simple type. They have single purchase, the construction being as follows. An endless rope passes round a grooved wheel of large diameter for the gain of power. The shaft on the end of which this wheel is keyed carries a pinion which gears into a wheel of considerably larger size, upon a second shaft that carries the chain wheel over which the chain passes, which carries at one end the cage, and at the other the weight by which it is balanced. A brake wheel is keyed upon the shaft of the chain wheel, and is operated by a cord and lever, the latter being pivoted on the first motion shaft. This constitutes the essential gear. The whole of the gear is carried in suitable brackets or cheeks attached to the wall, or to timbers in the upper portion of the building. The cage is guided by rollers between vertical rods or timbers, and the balance weight slides between timber guides bolted to the wall. The weight is usually made to slightly counterbalance the lift, so that the cage when empty will on the release of the brake slowly ascend.

Nothing very heavy can be attempted with hand-operated lifts, nor can their movements be rapid. An alternative design for lifting in warehouses and breweries is the basement lift, in which loads up to 10 or 15 cwts. can be hoisted from cellars by the aid of a light crab. The load platform is carried by rollers on vertical guides, and a monkey wheel changes the direction of the hoisting chain from the crab to the platform.

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CHAPTER XVIII.

PORTABLE CRANES.

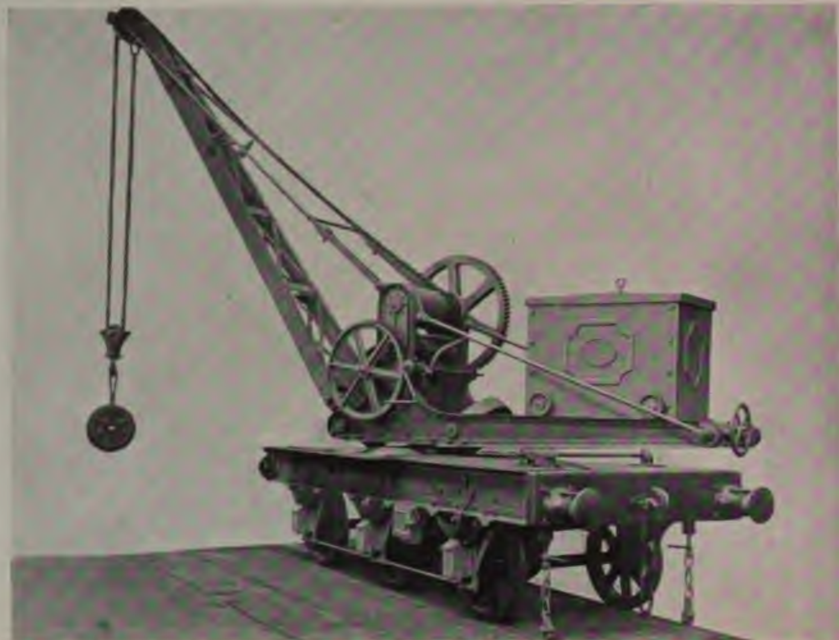
Balance Cranes—Derricks.

BALANCE CRANES.

THE earlier cranes were all fixed, but these are now in a minority compared with those that are portable. The earliest examples of the latter type simply comprised cranes of fixed type, mounted on a four-wheeled truck. These are retained yet in many country districts and provincial works. They are common on the wharves of quarrymasters, and at some railway sidings. Being portable, they must be balanced cranes, since a counterbalance is the only device by which the mass of the jib and load can be rendered stable.

Balance cranes, Fig. 189, though common, are so diversified in design, that we meet with much variation in the methods of counterbalancing them. Usually the balance is fixed at one radius. A good many hand cranes have been made with balance fitted with rollers A, by which the balance boxes and their contained weights can be traversed along the tail of the crane to various radii, to correspond approximately with a given load. These are common to a host of cranes, especially railway breakdown cranes. But the putting of automatically adjustable balance weights on cranes has never met with much success, the later application of that principle to the Brown cranes excepted.

In almost all cases cranes are counterbalanced with a number of loose weights which can be loaded in by hand.



Permanent-Way Hand-balance Crane.

(Thomas Smith & Sons, Rodley.

[To face p. 200.

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A crude device is to make a box, fit it on the tail of the crane, and load it with stone. But cast weights are generally supplied, uniform in size and shape, and loaded

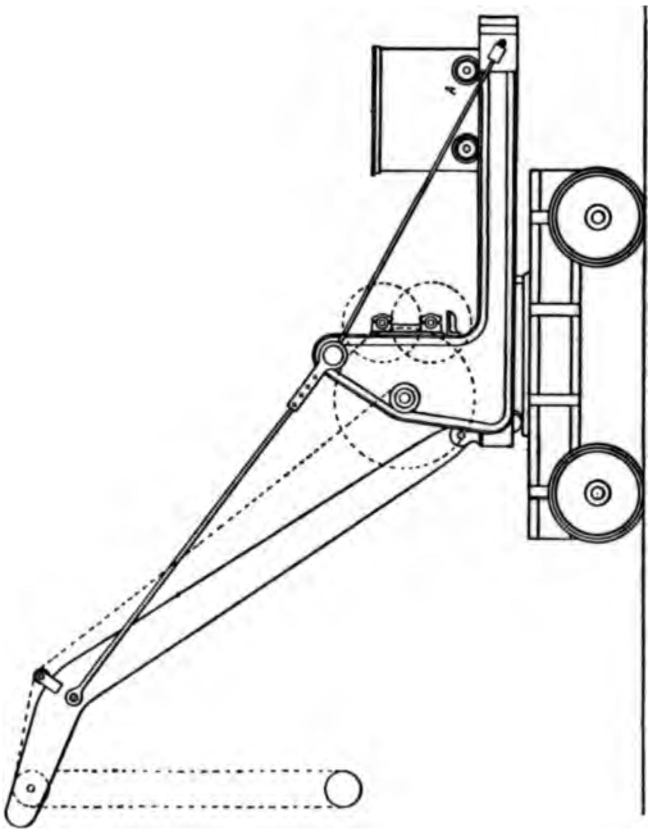


Fig. 189.

either into a box in hand cranes, or under the footplate in steam and electric cranes. Sometimes so much balance is required that wing plates have to be fitted, standing out

to right and left, wider than the crane itself, and loaded with weights.

Balance boxes are made in various ways; in cast iron in one piece, or with separate cast-iron plates bolted together, or plated in iron and steel. The first two are suitable for common cranes, the latter for breakdown cranes used on permanent way.

An objection to putting an excessive amount of balance on a crane, which is sometimes done to mask a bad design, is the great risk of its causing oversetting. When the crane is not working it is sufficiently stable. But if a load is lowered, and dropped, and disengaged suddenly, as in tipping, the reaction is very likely to cause the crane to tip over backwards, an accident which occurs occasionally. The danger is greatest when the crane is lifting across the track, or diagonally.

DERRICKS.

Portable hand derricks are employed to a moderate extent only. They are very ungainly articles to travel, because the spread of the guys renders three tracks necessary, one under the post, and one for each wheel under the guys. They are only to be recommended for temporary service. If portability is essential, it is generally better to adopt some other type than the derrick crane.

CHAPTER XIX.

TRAVELLING CRANES.

Overhead Travellers—Goliaths.

THESE are broadly divisible into two types,—travellers that run on overhead gantries, Goliaths, and gantry cranes that run on the ground.

OVERHEAD TRAVELLERS.

These have been a favourite type of crane for workshop service for more than half a century past. But for the inroads made by electricity, the hand traveller would still divide favour with the cotton rope type to a far greater extent than it does. Although hand travellers are open to the objection of being very slow, yet they have the advantage of costing nothing when not in actual service, and an engine need not be kept running to supply them with power. For this reason they are even yet better adapted to the requirements of hundreds of shops and yards than the more costly, and more easily damaged electric travellers. Rope travellers did not become common all at once, the square shaft types having been much used previously. The reason is that the cotton rope demanded a special experience, and a better class of workmanship than most crane shops could furnish.

The hand travellers are either built of timber or of steel. The question of trussing, and its extent, depends on its span, and on the design of the girders. When timber is used, trussing is essential for the shortest spans, but it is not necessary when steel is employed, because the longest

girders can then be made self-sustaining. When rolled joists are used, trussing becomes necessary at moderate spans, When timber beams are employed, the end cradles are generally of cast iron.

A special type of crab is required for travellers, one to run along rails, and usually, though not necessarily, having provision for travelling the machine along the gantry. The crab and the jenny are two different mechanisms, since the first named is self-contained, while the second is simply a carrier for the hook and snatch block, being operated by mechanism situated elsewhere.

There is, as regards essential mechanism, such as framework and gearing, no difference between the simple hand travellers worked by men on the platform, or by men standing on the ground below. It is simply a question of winch handles, or vee'd sheave wheels.

The question of operating travellers from below, or above, is generally decided partly by the load to be lifted, and partly by the nature of the service, whether intermittent, or constant. Light travellers working intermittently should be worked by a dependent rope or chain, heavy ones, by men on the crab above.

When travellers are actuated wholly from the crab, a square shaft, or a round one, key grooved to carry the sliding bevel wheel, is necessary. But for occasional service, a simpler design can be used in which the crab is traversed by gearing upon it, and the traveller operated by winch handles at the sides.

Hand travellers are made in powers ranging from $\frac{1}{2}$ ton to 40 tons. The latter are, however, unusual, more so now than formerly. They are constructed readily enough, but the time losses in working are enormous.

Goliaths.

This term strictly designates a travelling crane, which differs from the overhead travellers only in the fact that it

runs on rails on the ground, instead of on tracks high above the ground. Substantially, therefore, the beams and crab arrangements are alike in each. The great difference lies in the alterations due to the substitution of **A** frames, or standards, for the end cradles of the travellers.

Goliaths can be travelled from the crab with a square shaft, as can travellers, but the movement has to be communicated through pitch chain and sprocket wheels, or shafts and bevel gears, from the top to the bottom of one or both of the framings.

In the simplest hand types,—the old Wellington cranes,—many of which are, however, very large and powerful, the operations are wholly from below. The travelling gearing is on the bottom booms, and the hoisting gear is on the vertical frames, the chains passing up to the ends of the gantry beams, and over pulleys to the jenny. A set of gear on one framing actuates the hoisting chain, and another set of gear on the other framing actuates the chain for racking the jenny along. Goliaths of this type are made from 2 or 3 tons, up to 40 or 50 tons capacity, and in a wide range of height, and span. They are useful in engineers' erecting yards, and in builders' and contractors' yards, for hauling heavy timber balks, and stones.

Goliaths have been made in which the crabs have been operated from the ground with dependent ropes, passing over grooved pulleys, similarly to some hand travelling cranes.

An evil to which Goliath cranes, even more than travellers, are liable, is that of cross working, which becomes more pronounced as spans and heights increase. Hence the length of wheel base must be amply proportioned. But even with a suitable wheel base, cross working will occur unless the end beams are secured very rigidly to the main beams, with which object covering plates and angle brackets are employed.

In some recent special practice, that of the Brown

Hoisting Machinery Co., cranes of very long span have their beams rigidly fixed at one end only, being pivoted at the other to permit of a limited amount of cross working without strain or injury.

The Goliath crane fulfils the same function out of doors that the traveller does within. The latter are used also on outdoor service, but this involves building a tall gantry, which occupies much ground. The Goliath on the contrary only requires rails, and occupies no more space than that on which it stands for the time being. Occasionally Goliaths are fixed, but the utilities of these are limited to the area which they cover.

DIVISION II.—POWER CRANES.

CHAPTER XX.

FIXED CRANES.

Crabs, Winches, Hoists, and Winding Engines—Steam Cranes—Triangular-framed Cranes—Wharf Cranes—Derricks—Fairbairn Cranes—Sheer Legs—Pneumatic Cranes—Hydraulic Cranes—Composite Cranes—Floating Cranes—Coal Tips—Lifts.

CRABS, WINCHES, HOISTS, AND WINDING ENGINES.

THESE have a close family resemblance. None of them are framed cranes, but all are derived from, or are obvious modifications of the common fixed crab. They are single, double, and treble geared. The principal differences in their designs and appearance are those consequent on methods of operation, of which three agencies are employed;—steam in the vast majority, gas (or oil), and electricity. Compressed air is also used to a considerable extent in recent years. The hoisting and winding engines have undergone great changes in design, in consequence of the multiplication of drums. In some American designs as many as six, or even eight drums, are fitted to a single hoist, while three or four are very common.

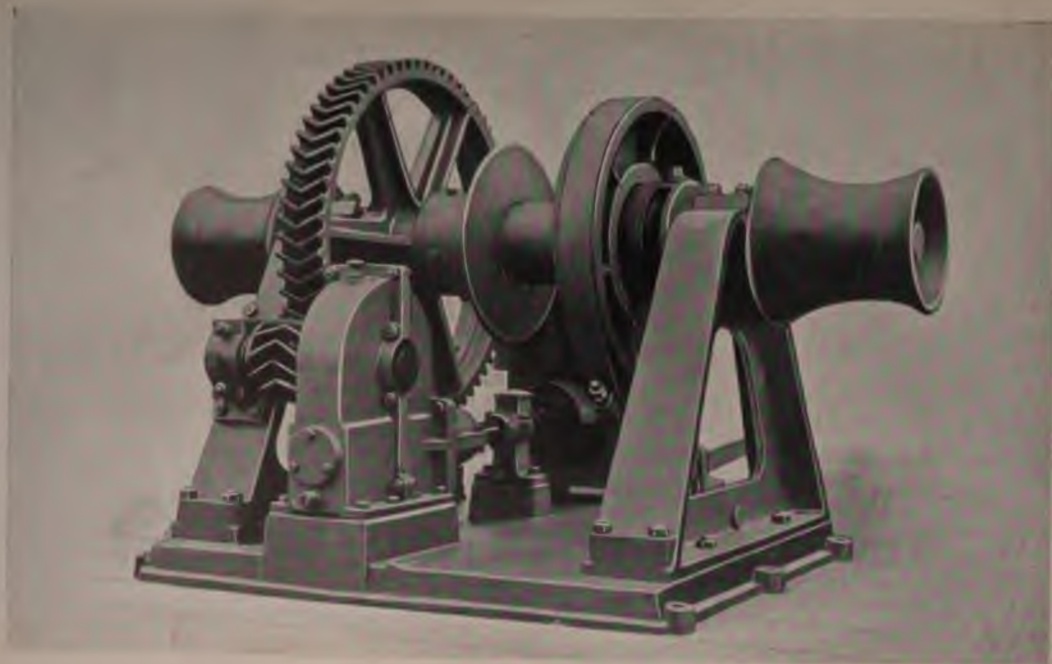
The simplest power crabs or winches are practically identical with those built for hand operation, but with a pair of engines added outside the frames. They bear strong resemblances to the steam cranes, with which much of their mechanism is identical, and interchangeable in manufac-

turers' designs. The same engines, boilers, and gears are used, the fixed bed plate of the hoist being substituted for the bed of the crane. As they are used frequently for hauling, or warping, warping drums are very commonly fitted on the ends of the drum shaft. The cylinders are variously arranged, with their longitudinal axes either horizontally, vertically, or diagonally. In many types they are bolted to the boiler. In a good many cases the boiler is not fitted to winches, but the steam is conveyed in pipes to the engines.

The various hoisting engines are built to satisfy the demands of a large number of customers. They are employed in the erection of buildings and bridges, for pile driving, on coal wharves, in mines, on shipboard, and in an extensive range of powers. The advantage of having more than one drum is, that more than one set of operations can be carried on at once. Lifting and lowering can alternate. A single engine can operate two or three separate derricks, or the two motions of one derrick at once. Plain drums, or warping drums, are multiplied on one hoist. They are either keyed fast on their shafts, which is the older and general practice, or they are left loose, to be thrown in and out of action with clutches, or with friction rings.

In one example a double cylinder engine has two drums running side by side on one shaft loosely, when not in service,—being of the friction operated type. Each is independent of the other, having its own friction, and its own foot brake. Each drum is actuated at its own side by a separate attendant operating his own throttle. The advantage is that a single boiler is used on the one bed plate, and the power of the engines can be applied to one drum, or divided between the two.

The hoisting engine when used in the erection of tall buildings is placed on the ground floor, and wire rope, passing over guides, actuates two cages, which ascend and descend in unison, balancing each other. Light vertical



Five-ton Electric Winch.

(CLARKE, CHAPMAN, & CO. LIMITED, GATESHEAD-ON-TYNE.

[To face p. 208.

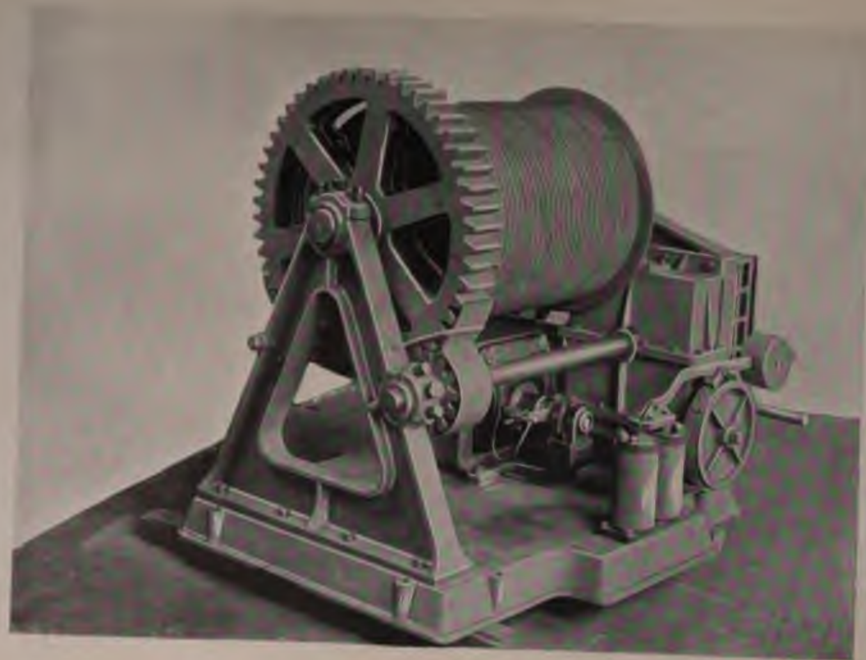
member along which a racking carriage travels. They are pivoted at top and bottom, and either slew through a portion, or the whole of a circle. They seldom have boilers on the foot plate, but steam pipes are brought to the posts to operate engines on the foot plate, or the engines are dispensed with, and a line of shafting is brought along the shop, and power is transmitted to each crane through bevel wheels. Of the three methods the steam pipe is best, but it introduces a considerable amount of joints, which are not easily kept steam tight. It is probable that each of these types of cranes will be displaced in a few years by those of similar form, but operated by electricity, as is done already in a good many cases.

Wharf Cranes.

This general term includes a large number of variations in design, ranging from a ton to 20 or 30 tons. In many cases the entire superstructure of a crane is used without alteration, for either portable, or fixed cranes, the base only being different. Steam is an excellent motive power for wharf cranes. These cranes are either independent,—containing their own boilers, and being balance cranes; or they carry engines only, which are supplied with steam through a pipe. Any fixed cranes used for wharf service are wharf cranes. They are characterised by the deep foundation in which they are supported, having base plates, foundation plates, and deep posts going down several feet below the ground line. Deck cranes are a variety of wharf cranes, used on shipboard. These also have a base plate on the upper deck, and step on the deck below, in which the post is supported. Steam is brought up to the engines through a pipe in the central post. These cranes slew through a complete circle by gear driven by the engines.

Derricks.

Steam derricks do not differ from hand derricks, except in the addition of engines, and the necessary connections.



Electric Hoist.

(MENCK & HAMBROCK, HAMBURG.)

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These are fitted to the base plate, or on the back of the mast. Engines are fitted to derricks framed both in wood, and in steel. A steam derrick carries its own boiler. In this class of crane the electric motor (see Plate overleaf) is rapidly displacing the steam engine.

Fairbairn Cranes.

This is not a triangular framed crane, but the curved jib and post are in one. There is neither strut,—nor tie rods, but the jib,—above the ground line,—is a bent cantilever. The advantage offered by this crane is the clearance under the jib, but as this is obtained in other cranes also, there is very little demand now for Fairbairns. At one time they enjoyed considerable favour, being used as wharf cranes for loading and unloading vessels, and for getting parts of engines into them. They are very expensive, require a large amount of plating, and castings, and costly foundations of concrete and metal. Steam is the motive power used, the crane carrying its own boiler, and is therefore independent.

Sheer Legs.

These are also termed masting sheers, because the fitting of masts is one of their principal functions. They are used in the great shipyards, and on shipping wharves, mainly for this work, and for lifting boilers and engines into and out of vessels. Heavy sheer legs are actuated by steam engines located at the rear of the back leg of the tripod, and properly covered in a shed. Provision is made for altering the radius, or reach of the hook over the water. The hinder leg is made capable of radial adjustment, by means of a slide into which the lower end is stepped, and which is traversed to and fro by a screw actuated by the engines. The front legs are hinged to permit of their adjustment. In heavy sheers, two sets of lifting tackle are generally fitted, one for heavy loads, the other for light.

The masts of sheer legs are generally built up in a tubular form, of steel plates. Only small sheers have timber legs.

The great 160 ton sheer legs at Sydney, erected about eight years ago, lifted 200 tons as a test load, and the legs are 137 ft. long, by 4 ft. 6 in. in diameter at the centre, built of steel plate.

Pneumatic Cranes.

Fig. 190.

These are chiefly used in engineers' shops, in the foundry, and machine shops chiefly. They have grown into considerable importance within about ten years past. Used first as suspended hoists simply, the same principle is applied to the operation of jib cranes. The air hoist is then suspended from a horizontal jib along which it runs, a flexible air tube following its movements. In some cases the air cylinder is set on a diagonal jib. In both instances the pull is direct, and the load is lifted through a distance equal to the stroke of the piston. In other cases the hoists are run along trolley tracks, coming then under the head of travelling hoists.

A Ridgway oil-governed hoist is shown in Fig. 190. Here a hollow rod passes through the hollow piston rod A, with a clearance space between the two. The rod is fastened in a reservoir on the top of the hoist cylinder, and the piston packing makes a close sliding fit over the hollow rod. A valve operated by a dependent chain coming from the pulley B, regulates the flow of oil between the reservoir and the hollow piston rod. The rod is filled with oil when

Electric Derrick Crane, Single Motor.

(THOMAS SMITH & SONS RODLEY.)

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the piston is in its lowermost position, the oil rising above the valve. Admitting air into the cylinder, and opening the valve, permits the oil to escape into the reservoir, following which the piston rises. As the piston descends by the load,

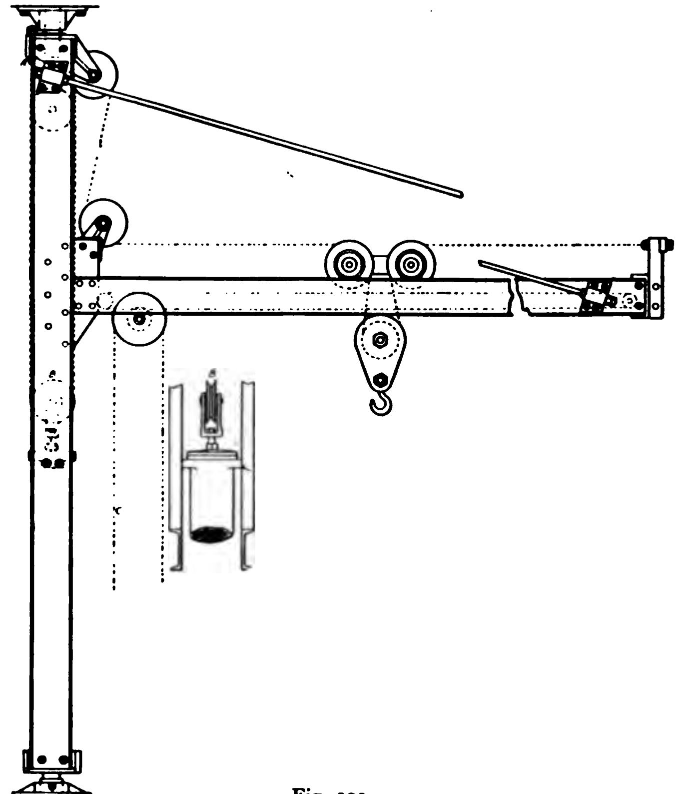

Fig. 191.

the oil returns into the rod. The rate of movement is regulated by the amount of opening given to the valve, which is under the control of the operator.

Fig. 191 illustrates a pneumatic crane by the Pedrick &

[redacted]

Ayer Co. Here the cylinder is fixed vertically between the members of the post. Hoisting is effected by the chain anchored at A passing round the pulley B, with a single

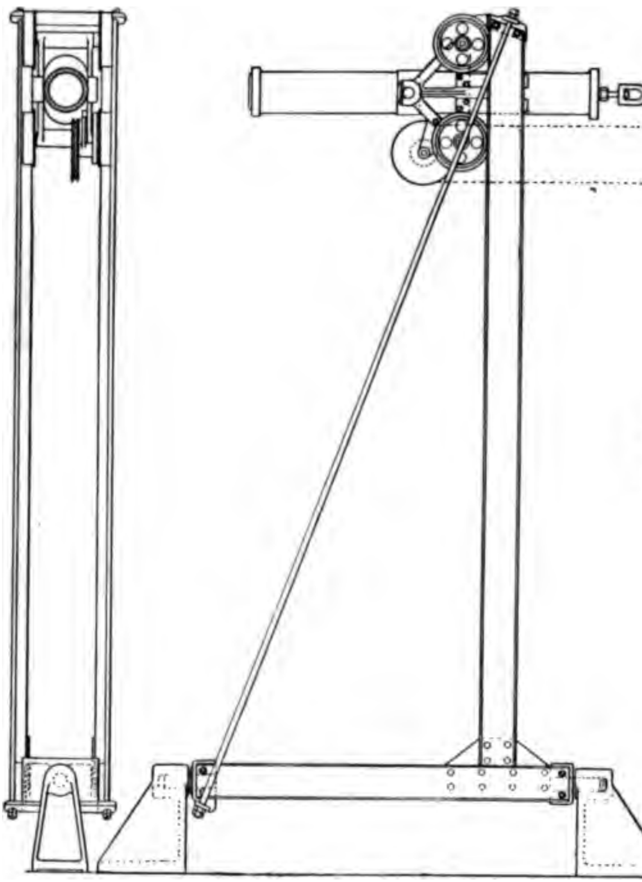

Fig. 102

bight, thence over guide pulleys to the racking carriage and snatch block. The carriage is racked by hand by the chain C.

Fig. 192 is a Pedrick & Ayer crane in which the lift is direct acting, the cylinder being suspended on trunnions, and drawn along the jib by gears, and a dependent chain. The crane is pivoted in brackets bolted to the wall of a shop.

Hydraulic Cranes.

Fixed hydraulic cranes are used for indoor and outdoor service. They are jib cranes, the jibs being horizontal in some cases, to take a racking carriage, diagonal in others. Separate cylinders actuate the lifting, and slewing movements. The dispositions of the cylinders are settled by convenience, and by swing arrangements, since the direction of movements of the chains can be readily altered by guide pulleys. The outlines of hydraulic crane frames frequently resemble those of the steam crane types, with posts, jibs, and struts. They are named similarly, as wall cranes, wharf cranes, ingot cranes, &c. A particular application in which hydraulic power has found great favour is in the riveting cranes which travel on rails with walking water pipes. These are made in several forms. Hydraulic cranes are made to rotate by power in cases where it is not desirable to have men pulling them round; a water cylinder placed horizontally below ground level has a rack attached to a continuation of its piston, engaging with a wheel keyed on the bottom pivot or pintle of the crane. In other types chains pass round pulleys from the piston head, and pull round a chain wheel at the bottom of the crane. In some types the lifting cylinders are fixed and the ram moves, the hoisting chain returning over pulleys from below upwards. Cranes of this type are also made with racking jennys.

Fig. 193 illustrates one type of hydraulic crane in which the lift is direct, by the communication of the movement of the ram A to the jib B. The smooth motion of the latter is ensured by the pulleys C, connected,—running on the back and front of the post. The racking carriage is

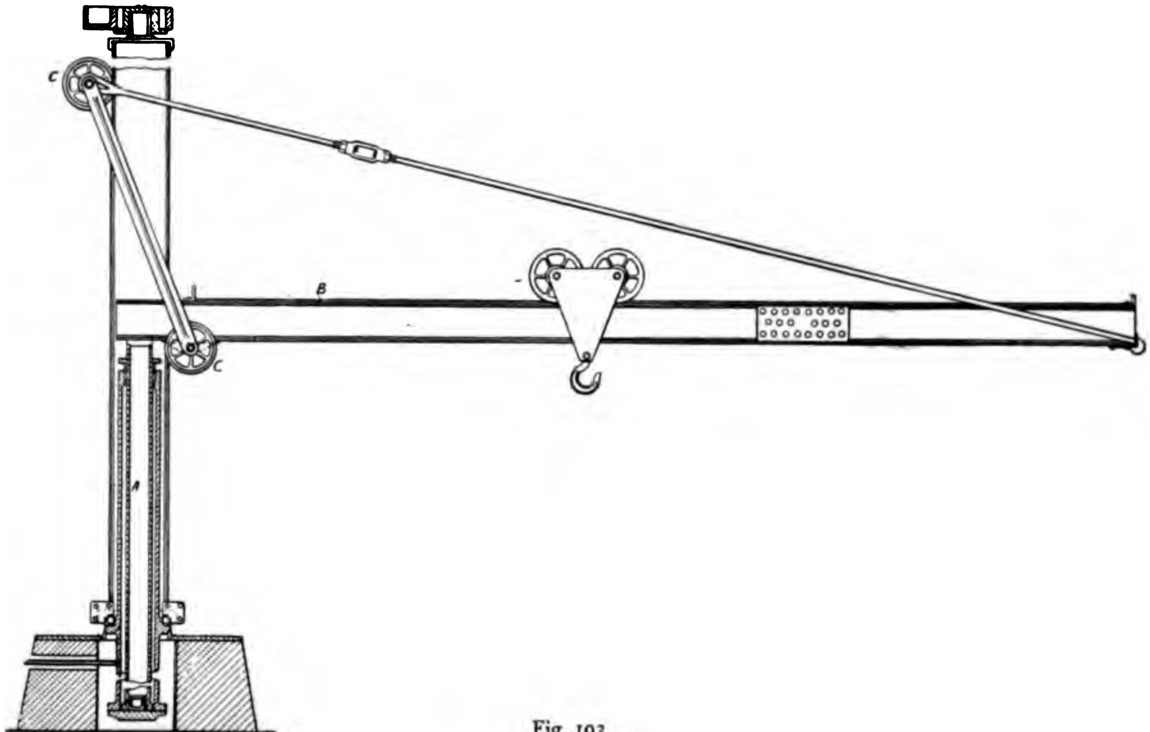

Fig. 193.

drawn along by hand. A good many of this simple type have been made.

Composite Cranes.

Besides the class of crane in which the elasticity of air is held in check by governing its action with oil pressure, there are others of the usual hydraulic type with the cylinder

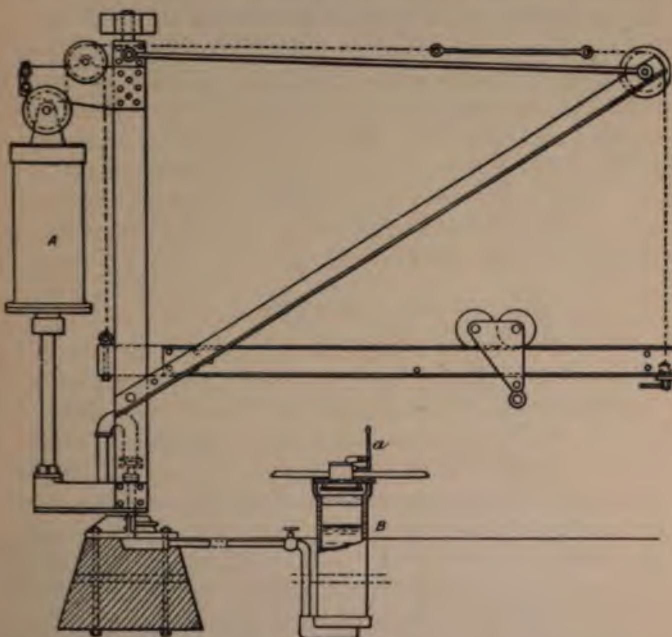

Fig. 194.

between, or adjacent to the mast, operating the jib directly, which are also governed by steam pressure acting on the water in the reservoir cylinder. The advantages over the common hydraulic type are to be found in the differences due to high and low pressures, saving trouble in valves, and packings, pumps, and accumulators.

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Fig. 194 shows a balanced steam hydraulic crane of the Craig Ridgway type. In this, A is the lifting or water cylinder, and B the governing cylinder, which is partly filled with water. Steam is admitted above, and is prevented from mixing with the water below by an intervening cushion of air, and by a baffle plate. The supply of steam is controlled by a slide valve, the handle of which is seen at *a*, and its pressure is transmitted through the air to the water below. The water, under pressure, is conveyed through piping to the piston rod of the lifting cylinder. The rod is hollow, and the pressure causes the lifting cylinder to descend over its piston. By means of chains passing over guide pulleys, this vertical movement is transmitted to the jib. This design is variously modified. The jib is lowered by exhausting the steam, on which the water returns from the hoisting cylinder to the reservoir.

Floating Cranes.

These are used for a large number of duties, the principal of which are loading and unloading vessels, executing repairs to machinery on board (thus saving the trouble of bringing the vessel into dock under shore cranes), and in various departments of harbour and dock work, such as grabbing, block setting, and repairs. They are not used quite so much as formerly, partly because of the general deepening of docks that has been going on, and partly because hopper dredgers and Titan cranes have usurped some of their other kinds of functions. But one at least is essential in large harbours and docks.

The floating cranes are balance cranes pivoted on a pontoon or barge. They may or may not have derricking movements to the jib. In consequence of the instability of the pontoon, provision is included for effecting alterations in the balance box to suit varying loads. Frequently too the hull is made in water-tight compartments, either with the object of altering balance, or to permit of changing

the amount of immersion of the hull to increase stability. Floating cranes are actuated by steam, carrying their own boiler and engines, and slewing by power.

Coal Tips.

These are a type of hydraulic lift used for elevating railway coal wagons from a cradle beneath, and tipping their contents into vessels. A 10 or 20 ton wagon can thus be lifted, tipped, and lowered in a very short space of time, effecting enormous economies in loading. These are the rivals of the long-armed cranes that deal with lighter loads.

Lifts.

Two principal agencies are employed for power lifts—water, and electricity.

Hydraulic lifts are of two kinds—the direct acting, and the suspended. In the first named the cage is carried on the upper end of the ram, in the second it is raised by ropes running over pulleys. The first requires a deep well for the cylinder, the second does not. The direct system is generally employed for heavy passenger and goods lifts, the second for ordinary duty. High, and low pressures are used for each. In the suspended system it is necessary to provide safety catches in case of sudden fracture of the ropes.

Lifts are frequently driven by belt in shops and warehouses where engine power is available. The design is practically that of a hand lift, with worm gears, but the belt takes the place of the hand rope.

Electric lifts are rapidly displacing these forms. In a simple type, an electric motor takes the place of the belt drive. The motor can be driven from the public service. In more modern types the motor and its gearing are mounted on a base plate, which can be fixed anywhere, above, or below. The drive is direct, from a rope wound round a drum. The mechanism is operated by a hand rope, or by a hand wheel, or simply by a switch. The electric lifts work at much higher speeds than the older types of belt-driven ones.

CHAPTER XXI.

PORTABLE CRANES.

Hoists and Winches—Balance Cranes—Excavators.

Hoists and Winches.

The fixed hoists far exceed in number the portable ones. The only essential difference in the two is, that either three, or four road wheels and axles are added to the fixed type, to make it portable. But usually only one class of hoist is made portable, that namely for builders and contractors' use, having boiler, engine, and single, or double hoisting drums and gears. In one example the portable type of engine and boiler is rigged up as a hoist, the drums hanging over to right and left of the boiler. In all cases the travelling of the hoist is effected by horse haulage.

Balance Cranes.

Portable balance cranes include those in which the hoisting engines also drive the truck. In the heaviest cranes a separate pair of engines are employed for the latter purpose. These are generally termed locomotive cranes. Special portable cranes are also built for service on permanent way, —the breakdown, or accident cranes used for removing the wreckage after railway accidents.

The portable balance cranes differ from the fixed cranes of the same class only in the extra fitting of the truck, and the extra gears, or engines used for travelling. That is, the [illegible] is similar in both, and may be identical if the

Overhead Electric Traveller, Single Motor.

(THOMAS SMITH & SONS, RODLEY.)

[*To face p.* 226.

travelling is effected by a different set of engines on the truck. But if one pair of engines does all the work, as in most cranes except the larger sizes, then a special set of travelling gear has to be introduced; starting from the engine shaft, thence operating gears above the central post, a shaft passing down through the post, bevel wheels at the bottom, and thence bevel wheels on one of the travelling axles. The methods of balancing are alike in fixed and portable cranes.

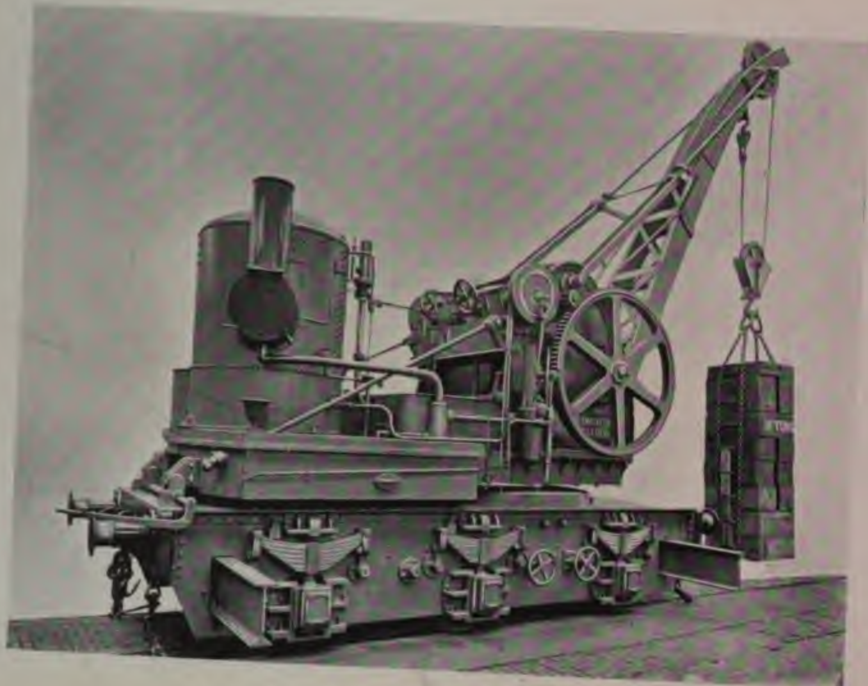
The horizontal type of portable steam crane not only has a very different appearance from the vertical, but the entire arrangements of framework and gearing are different. The exception is the truck and jib, neither of which differ in any essential respects from those used on vertical cranes.

The framework which carries the engines and gearing is not formed of cheeks bolted together with cross girders, but is usually made in one casting, excepting in the largest cranes, and is termed the revolving bed, because it turns round the centre pivot or dwarf post, being thus distinguished from the truck, or base, which does not revolve. The upper, or revolving bed is a hollow casting, with bearings for the engine shaft and gearing, axles, and facings for the attachment of the engines. Wrought-iron girders are bolted to the sides of the bed, extending beyond the hinder end to carry the footplate and boiler. A heavy cast-iron tank is bolted between the girders to hold the feed water, and to serve as a balance weight. The engines comprise a pair of high-pressure cylinders, sometimes cast separately, sometimes together. The cylinder guides, and steam chests are made in one, and cast with a foot for bolting down to the bed. Link reversing motion is applied to each. The load is lifted through spur gear, the pinion being on the engine shaft, and it is slid out of engagement when lowering on the brake. The gear for these functions is similar to that employed on the vertical cranes. The slewing is performed through bevel wheels, fitted with reversible friction cones, in order to slew in either direction without stopping,

or reversing the engines, the movements being transmitted through intermediate gears to the curb ring on the truck. By reversing the direction of rotation of the bevels, the direction of rotation of the revolving bed is reversed. The truck is travelled by means of a separate set of gearing which actuates a bevel wheel on one of the axles. Jibs are made to derrick. The revolving bed runs on four rollers, two at front, and two behind. It is kept from lifting by means of a dwarf parallel centre post, or pin, which passes through the centre of the truck below, and through a bored hole in the centre of the revolving bed, in which it fits with a solid forged head on a shoulder with friction washers—a massive nut securing it at the lower end tightened up in opposition to the bolt head just sufficiently to keep the revolving structure well down on the roller path. The water tank and boiler are sufficient balance in cranes with short jibs. In those with long jibs a special balance plate is cast, and bolted underneath the tank, and loose weights are laid upon this.

Many portable steam cranes are made of from 2 to 3 tons capacity, for regularly lifting loads of from 30 cwts. to 2 tons. Some of these, used for coaling, have jibs of exceptionally long radius, and they lift in single gear, that is with the crank of the engine keyed on the same shaft as the pinion that works into the barrel wheel. The drums are also made of larger diameter than those of the average class of crane.

The electric type of portable crane is growing in favour. The motor or motors are mounted on the bed plate in place of the engines and boiler. Either plain spur gears, or a first worm reduction, is employed from the motor. The magnetic brake is an essential portion of the equipment, as in other types of electric cranes, and the controllers are mounted in a convenient position for the operator. A very compact arrangement is thereby secured. Rather more balance weight has to be used, as the large mass of the boiler is absent in the electric crane. With



Sixteen-ton Permanent-Way Steam Crane.

(THOMAS SMITH & SONS, RODLEY.)

[*To face p.* 282.

regard to the method of picking up the current while travelling, this may be either done from a third rail, overhead wires, or from ground or earth boxes. An example of the latter is shown in the diagram, Fig. 195, from the practice of the Electrical Company Ltd., of Charing Cross Road, W.C. The amount of portability or travel in this case is governed by the length of cable which is rolled on the drum G. In the illustration, C is the lifting motor, and D the one for slewing. A is the controller for the lifting, and B that for the slewing. E is the switchboard,

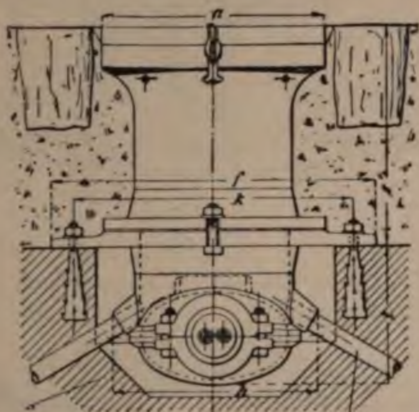


Fig. 196.

F the magnetic brake. H are the collecting rings, which are necessary in the case of a slewing crane, to take current at any radial position of the superstructure. J is the ground box. This is shown in detail in Figs. 196-198, in elevation, vertical, and transverse sections. It is bolted down in masonry, or concrete with jagged bolts. The current is brought in at each end of the box with cables, and thence conveyed upwards into the upper part of the box to the contact pieces. When the box is in use, a plug piece, at the end of the crane cable, is inserted in

the top of the box in place of the temporary protecting cover shown in Fig. 197, and it has projections similar to those in the box, and so the current passes to the crane

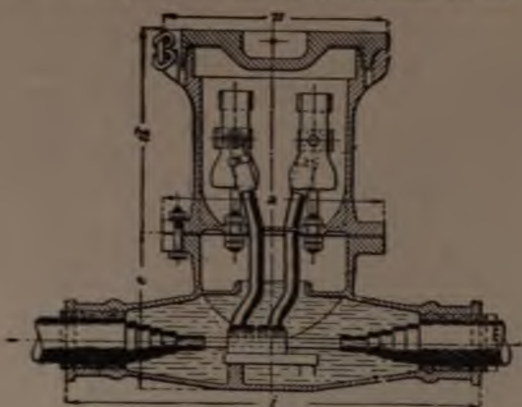


Fig. 197.

cable. These boxes are located about in the areas required for the service of the crane, and when it passes out of the limit of area of one, another is connected up to

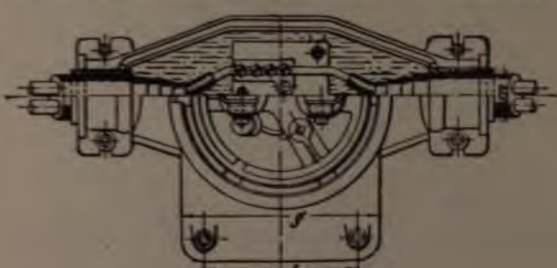


Fig. 198.

it. (The lettering shown in these Figs. simply refers to the maker's standard sizes.)

Fig. 199 shows the jointing, and the contact rings of a trolley pole, suitable for slewing cranes.

Electric Horizontal Crane, Single Motor.

(THOMAS SMITH & SONS, RODLEY.)

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EXCAVATORS.

These are a special type of portable steam crane used for digging soil. They are more often termed steam navvys. They are either special machines, designed for excavating only, or they are cranes from which the excavating apparatus is readily detachable. Excavators are balance cranes, with derricking jibs, and the bucket is hinged, and operated by the engines.

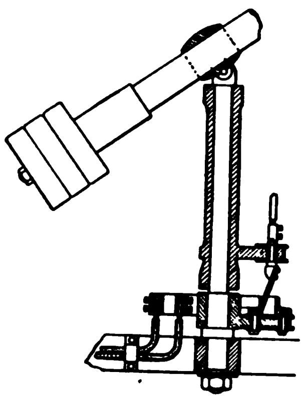

Fig. 199.

DERRICKS.

Portable derricks are rather unusual. They are clumsy and costly. Either each guy leg and the mast have to be carried on separate trucks, or a very large truck has to be made to receive them. As the guys cannot be anchored to the ground with sleepers, a large amount of ballast is necessary. The truck is propelled by the same engines that hoist the load. Floating derricks are sometimes built for special service.

CHAPTER XXII.

TRAVELLING CRANES.

Overhead Travellers—Goliaths—Gantry or Portal Cranes—Titans—Air Hoists—Long-armed Cranes—Single-rail Cranes—Conclusion.

OVERHEAD TRAVELLERS.

AN unusual amount of interest has been taken in overhead travellers of late, due to the fact that electricity has made greater inroads on the method of operation of this type of crane than on that of any other. To a great extent it displaces the hand, steam, and cotton rope types.

But for the fact that so many travellers of these older types were in existence, and in good working condition at the time of the introduction of electric driving, it is probable there would never have been any rivalry between the one motor, and the three, or more motor type. Firms already having travellers as good as new did not care to throw them out, and so the obvious and easiest course was taken of dispensing with the hand gear, or the square shaft, or the cotton rope, and putting a conductor and motors in place, and transmitting all the motions by reversing bevel gears, or by belts as before. Then of course conservative firms built new travellers on the same design.

It was little short of a marvel that the electric traveller was not strangled in its birth by the methods of firms who thought by merely substituting a motor for a shaft or rope, to obtain a short cut to electric driving, with no trouble in working out a new design. And the motors were high

speeded, and shunt wound, and kept running continuously at a rate anywhere between 1,000 and 1,500 revolutions per minute. All the heavy trains of reversing gear, or the belting were retained, so that the only advantage lay in the knocking out of a length of square shaft, or a running rope. This crude arrangement was the only practicable one when the question was that of the conversion of existing travellers. To dismantle all the gear of these in favour of simpler arrangements would have been nearly equivalent to the construction of a new crane. But the mischief lay in the building of new cranes precisely after the designs of conversions. Purchasers of new cranes were entitled to something better than this.

The most important fact in the development of the overhead traveller is the rapid growth of what is termed the three-motor type; though that phrase is no longer sufficiently comprehensive. A modern crane often has four motors, and in the case of very heavy types, sometimes more. There is a separate motor for each motion, suitably proportioned to the work required for each motion. All the old gear used for reversing, and much of that for high speeded reduction, is knocked out, and the phenomenal growth of the all-electric traveller is due to this multiplication of motors, and simplification of gears.

The first trouble arose in consequence of these complicated arrangements, coupled with the fact that the speeds of the motors were much higher than those of the pulleys for ropes, and the square shafts which they displaced, so that much reduction gear became necessary, with loss of power due to friction. Whether belts, or bevels, or worms were used made little difference, the results were equally unsatisfactory, and the various devices,—and they were numerous,—adopted to prevent belts from slipping, and gears from being noisy and self-destructive, have been nearly superseded by the newer designs of the all-electric types. Series-wound motors were being used by some firms when others were still

employing the shunt-wound type. The advantage of their use is seen in lifting a wide range of loads anywhere from the maximum downwards, at suitable speeds without changes of gears, by the variation in the speeds of the motors, regulated by the controllers.

The point in favour of a one-motor traveller was thought to be akin in one respect to that of a crane driven by a single pair of engines. The engines run in one direction, and the crane motions are reversed by clutches, and gears, or belts. On the electric crane, since the single motor took the place of the engine, at first it seemed natural and proper, and certainly it was then more convenient to crane-makers, and to owners of existing cranes requiring conversion, that the crane should be reversed similarly. From that point of view it seemed better to reverse the gears than the motor. At the period of which we speak, and with the motors then available, perhaps it was the better course.

The entire absence of worm gears from some modern travellers is noticeable, spur wheels being substituted. This gear answered fairly well for driving slow-running crabs, but with increase in speed, the friction proved excessive, and the advent of the electric cranes rendered the immersion of the worm in an oil bath, and the taking of end thrust with friction washers or ball races, essential.

Worm gear is retained on converted travellers, and on new ones of that type, just as on those of ordinary design, for the purpose of transmitting motion of the crab. The difference, however, is, that the older worms were always single threaded, while into later practice the employment of double, and even treble threaded ones has been introduced. The result is that the first are self-sustaining in any position, while in the latter it is possible for the worm to be revolved by the wheel when a load is on. The first arrangement is seldom now put on new cranes, the second is supplemented by a brake, or brakes. When spur gears are used, smoothness of running is ensured by using cut gears.

In several electric travellers now there is a third lift entirely independent of the main changes. It is an auxiliary light hoist, having its own motor, for very rapid lifting of light loads,—an addition by which the utility of the electric traveller is much increased.

There are many other differences between the slow-running hand, or power travellers, and the present high-speeded electrical ones. Notable among these is the difference due to increase in travelling speeds. In the older types lateral stresses were almost neglected, because there was little tendency to overset, or to twist. In the new it has been necessary to give special attention to lateral rigidity. The most striking design of this type, is that first adopted by the Brown Hoisting Machinery Co. Inc., in which the main bridge girders are stiffened laterally with horizontal trusses, flanking the outsides at top and bottom, these trusses being connected with diagonal bracing, the combination being both exceptionally stiff and light. Travellers should be, but are not always properly tested before being sent out. Testing pits are excellent devices.

Fig. 200 shows the wiring for a traveller for continuous current, the example being by the Electrical Co. Ltd. It has three motors, A being the lifting, C the one for travelling the crab, and D that for travelling the bridge. The three controllers are seen in the cage, E being for the bridge motor, F for the crab, and G for hoisting. H is the switchboard, J the fuses, K the collecting rollers for the longitudinal travelling, L the conductor support, M the sliding collectors for the crab, B is the magnetic brake. The courses of the wires can be traced by the reference letters A^1, B^1, &c.

Fig. 201 (see overleaf) is the wiring for three-phase current in which the same reference letters denote the same details of the electrical connections.

Figs. 202 and 203 illustrate two styles of conducting wires for travellers, from which the current is picked up by rollers. Insulations differing in type are used in each. The difference

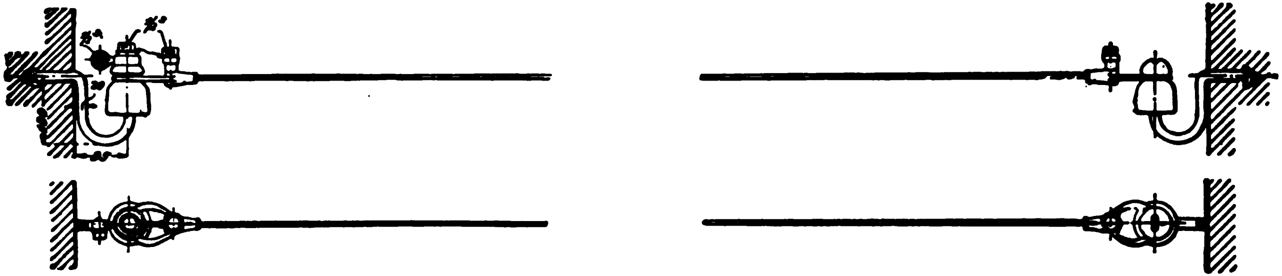

Fig. 202.

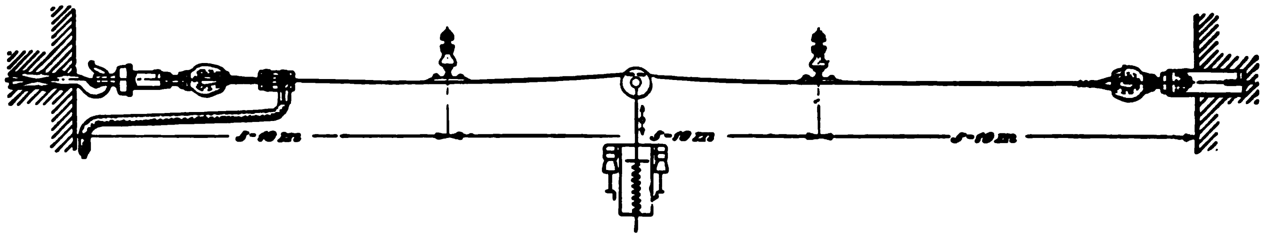

Fig. 203.

in the tension bolt systems will be noted in Figs. 204 and 205.

Figs. 206, 207 show three-phase collecting rollers made for cranes; the spring arrangement is seen in Fig. 207. All these are by the above-mentioned Company.

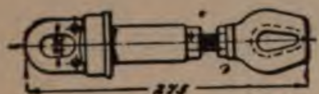

Fig. 204.

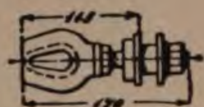

Fig. 205.

Fig. 208 shows a collecting pole and trolley contact by the British Thomson-Houston Co. Ltd., of Rugby. A is a wrought-iron tube which forms the trolley standard, fastened with a flange B to the traveller girders. C C are angle-iron brackets,

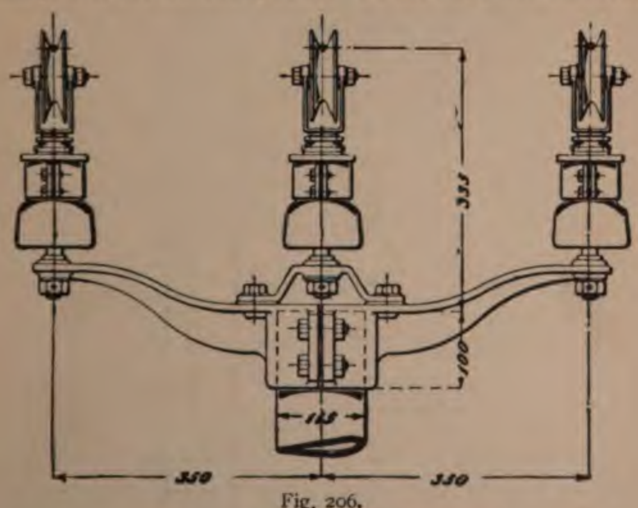

Fig. 206.

D D are wrought-iron trolley wire holders, E E the insulating stalks, F F cable terminals of gun-metal, G G porcelain insulators, H H trolley wheels, or collectors, which are so arranged as to raise the copper wire when passing under it, thus using the

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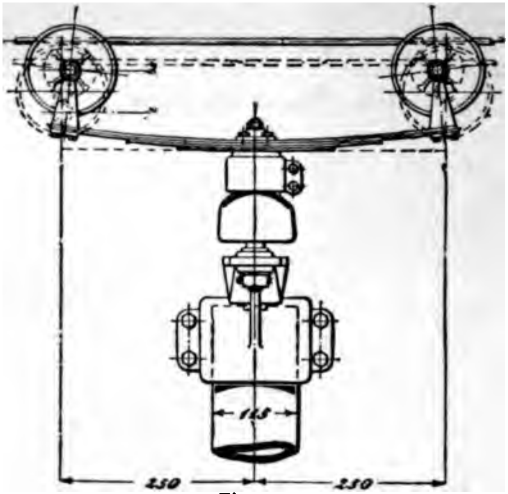

Fig. 207.

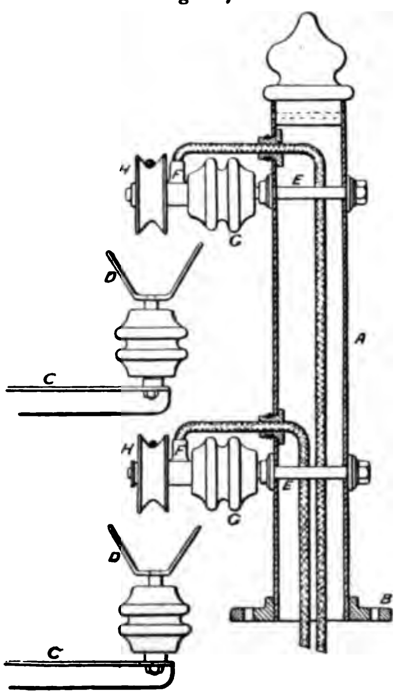

Fig. 208.

weight of the wire to obtain good electrical contact. This is an alternative to the spring pole.

Wiring for a three-motor crane by the same Company is

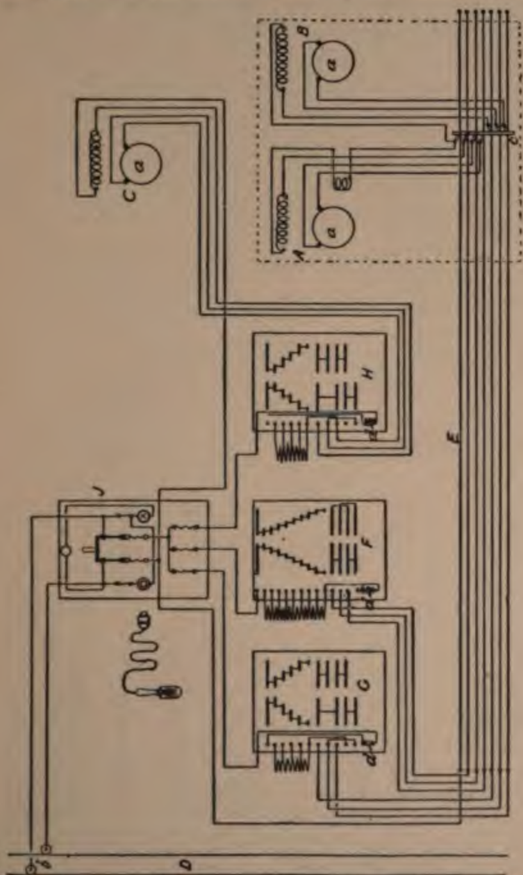

Fig. 209.

shown in the diagram in Fig. 209. Here A is the motor for hoisting, B that for cross travel, C that for longitudinal travel, *a*, *a*, *a* representing the armatures. D indicates the main

[redacted]

trolley wires, down the gantry; E those across the span, for actuating the motions of the crab; *b* indicates the trolley

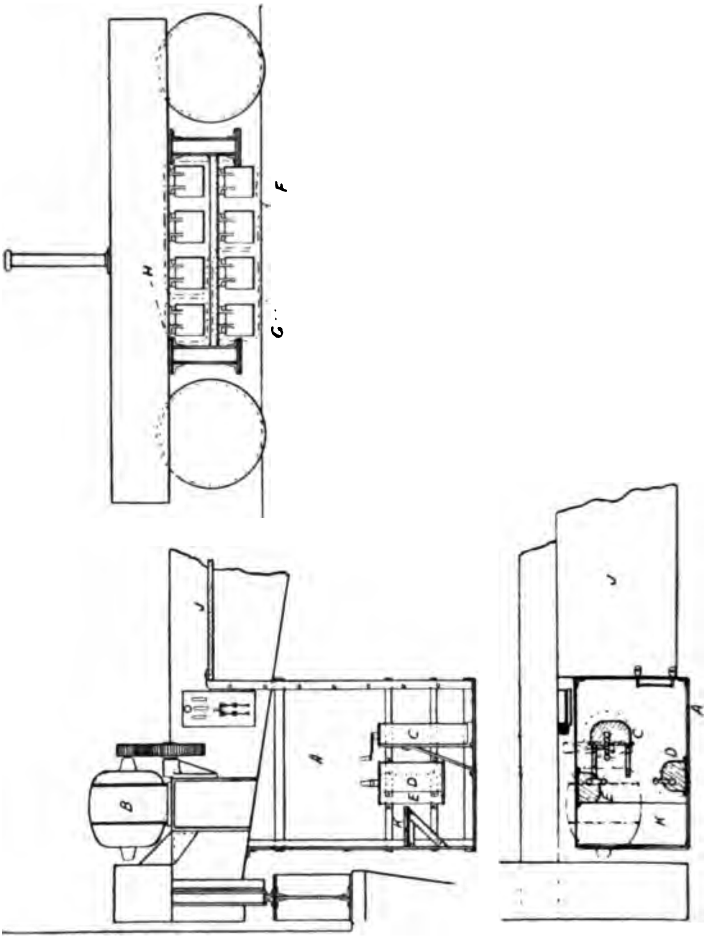

Fig. 210.

wheels for taking current; *c* the collector on the crab, F, G, H, are the controllers for hoisting, cross travel, and longitudinal

travel respectively. Each has a magnetic blow-out coil at *d*, which prevents an arc occurring at the contact surfaces on the making and breaking of the circuit, thus reducing the wear of these surfaces to a minimum. J is the switch-board in the cab, controlling the power, and light, each with its own fuses.

Fig. 210 illustrates the arrangements of controllers and resistance boxes of a traveller fitted by the same firm, the drawing showing the cage A fitted at one end of the traveller. The longitudinal travelling motor is seen at B; C, D, and E are controllers for the hoisting, longitudinal travel, and cross traverse respectively. Frequently the resistances are included in the controller boxes, but here they are separated, as being a more convenient arrangement. They are placed between the traveller girders at one end, shown grouped at F, G, and H for hoisting, longitudinal traverse, and cross traverse respectively. J is the platform, and K the driver's seat.

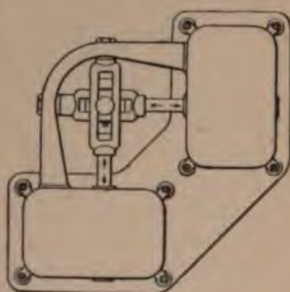

Fig. 211.

Fig. 211 shows a typical method of connecting the levels of two controllers with a universal joint, so that one handle can be used to operate either alternatively. It is also applied to the operation of three controllers with a single handle, and has the effect of simplifying the work of the driver. These are applied to many types of electric cranes, including travellers. The wharf cranes of the gantry type are very commonly fitted with this style of coupled controller, and in arranging the levers it is generally possible to make them to move in the direction which the crane has to go. Thus, for hoisting, the lever is moved upwards, and for the travelling it is moved in the direction in which the crane is desired to move. The possible objection that the

driver may move the lever in the wrong direction does not seem to be borne out in practice as a serious matter. The advantages outweigh any such possibility, and the operator is able to devote more attention to the load, than when he has three separate handles to reach for, and operate.

Fig. 212 illustrates a magnetic brake by the Electrical Co. Ltd., in which a small air cylinder below allows the brake band to go on gently without shock. When the current is passing the keeper is held up against the magnets, and the brake band is held off. Should the current be cut off, or fail, this keeper falls away from the magnets, pulled down by its own weight, and that of the balance weight on the lever; and driving the air from the cylinder, so puts the brake on gently. There are numerous details special to electric cranes which it is impossible to go into in the limits of this work. They would require a special treatise on that subject alone.

Three-motor travelling cranes operated by compressed air are used in the States. The motor consists of a couple of oscillating cylinders at right angles, driving on to a crank in an air-tight case. The air ports are opened and closed by the oscillation of the cylinders, and they are controlled by a slide valve which starts or reverses the motor.

GOLIATHS.

The steam Goliath has been, and is still a valuable machine. It resembles and fulfils the same functions as the hand Goliaths, but with the difference due to the nature of the motive power employed. The steam Goliath, like the hand, has a crab, or else a jenny. In the first case the engines and gears are carried on the crab, in the second they are situated at one end of the beams. Steam Goliaths are therefore operated from above.

Apart from this, the general design of the framing is that of the hand Goliaths. The crab is similar to an ordinary

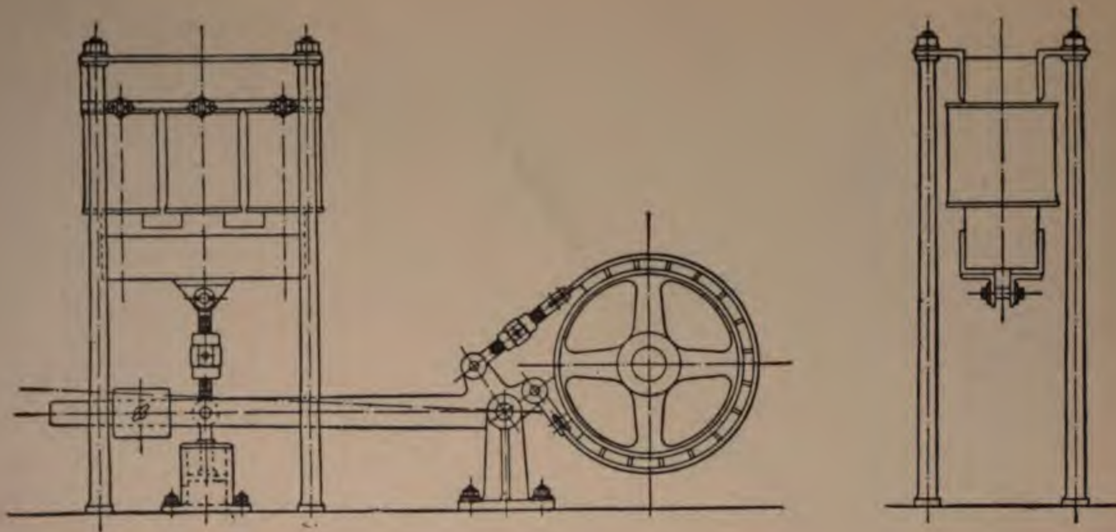

Fig. 212.

steam crab. The same patterns are in fact used interchangeably on the crabs for travellers and Goliaths.

The common type, with rigid end fixings, is unsuitable to many classes of work, for which spans of over 80 to 100 ft. are desirable. The pivoting of the bridge girders to the piers of the Brown cranes enables them to make gantries of longer span than heretofore, spans ranging up to more than 200 ft. These cranes, with powers of from 5 to 10 tons, will hoist with full load at rates from 100 to 300 ft. per minute, will trolley at from 500 to 1,200 ft., and travel at from 300 to 900 ft. These cranes are used in steel works, and for shipbuilding, sometimes with a cantilever extension at one end. Electric driving has been applied to Goliaths to a considerable extent. The arrangement does not differ greatly from that of overhead travelling cranes. Two motors on the crab for hoisting and travelling the latter, and one on the bridge for travelling are fitted. The current is taken from a suspended wire some distance up the sides of the Goliath, the rolling contacts and other details being similar to those of travellers.

Gantry or Portal Cranes.

The old Wellington cranes or Goliaths were, and frequently are, termed gantry cranes. But the term should be properly restricted to that type which the Germans call Portal cranes. These have received their chief development in Germany, simultaneously with the growth of electricity, by which they are almost exclusively operated. But they were first designed as steam cranes. Essentially they comprised a steam-balance crane pivoted on a bed, mounted on a tall arched travelling frame, the latter simply taking the place of the low truck of the ordinary steam-balance crane. The object of the tall frame is of course to clear lines of trucks below, by reason of which the portal crane is a great favourite on wharves, and dock walls; on many of

Electric Gantry Wharf Crane at Copenhagen.

(NAEGEL & KEMP COMPANY LIMITED, HAMBURG.)

[To face p. 238.

which a row of such cranes are installed. Any other type of frame could not be used, and still leave room for a line on which railway trucks may run. But having the arched form, this traffic may be carried on regardless of the cranes, or the latter may load and unload the trucks from vessels. The cranes are travelled from above through bevel wheels, and shafts, or sometimes by pitch chains, similarly to Goliaths.

TITANS.

Titan cranes are a very special type designed for handling and setting the blocks of concrete used in harbour construction. They range in power from about 20 to 100 tons, the greater number made being built for blocks ranging from about 30 to 40 tons. There are several types, the chief division being that into non-rotating, and the rotating;—the latter being either capable of describing a complete circle, or a portion only of one. In some Titans the horizontal jib is sustained wholly on the framework of the base, and is therefore a cantilever machine. In others the ends are supported with rods coming from the top of a king post. Titans are balance cranes. They are driven mostly by steam, one set of engines lifting, slewing, and travelling. Electricity has also been used.

AIR HOISTS.

There is no essential difference between the fixed hoists, and those that travel. The differences lie in the pipe and track arrangements. These are termed trolley systems, and they fill a large place in some foundries, and machine shops. The tracks are rails, of H, or U sections, attached to the roof principals, or beams. In a well-arranged system, switches and turntables are fitted, and automatic safety stops.

Fig. 213 illustrates a method of fixing overhead tracks adopted by the Brown Hoisting Machinery Co. Inc. As

stability is of the first importance, and then clea
for the trolley wheels, both are fulfilled by this d
hanger bolt A is held with a cottar *b* below, and
on a broad washer above the timber.

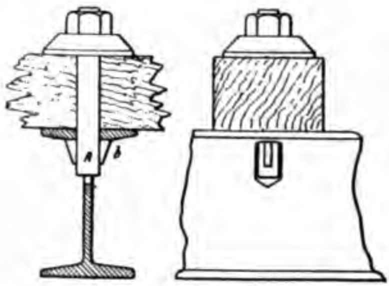

Fig. 213.

Fig. 214 shows a trolley carrier with a dou
joint to permit of swivelling round curves. The
in roller bearings. The shape of the track is

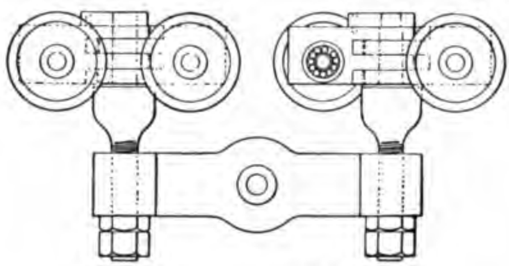

Fig. 214.

This is the Coburn track, and the system to whic
is a very complete one, including three desig
these only is shown in Fig. 215. Here the

Thirty-cwt. Temperley Transporter.

[To face p. 242.

supported by light truss framings B, at the ends. The longitudinal carriers C combined with the cross traverse movement of the double carriers D D cover the floor area, similarly to an overhead traveller. In another system, parallel tracks are suspended from H beams. In a third, single tracks are arranged, both straight, and curved, with switches, and turntables.

LONG-ARMED CRANES.

In recent years some remarkable types of long-armed cranes have been developed, chiefly for dealing with light loads with great rapidity. The Temperley transporters are long jibs attached at a position to one side of the centre of

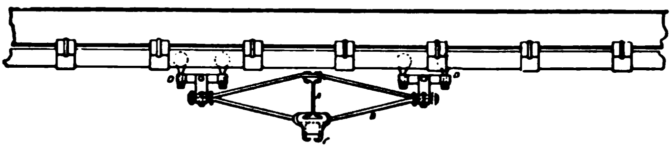

Fig. 215.

their length, to a mast or tower, which is either permanent or temporary. They are pivoted, and the ends supported with guys or tie ropes. The hoisting trolley runs and dumps the load automatically. There are several types of these built. The Brown cantilever cranes are elevated tramways supported at about the centre, and the trolley is travelled, and discharges automatically. There are several varieties of these built.

SINGLE-RAIL CRANES.

These are built to run down the centres of shops, machine shops chiefly. They are post cranes, the post describing a complete circle. The jib is horizontal, the tie being above.

Such cranes are operated by hand, or by the cotton rope and latterly by the electric motor. These have long been favourites, but it is doubtful if they will not be displaced in a few years by the overhead travellers. They are used chiefly to pass down aisles of machines, where a traveller is not easily employed.

Four-ton Bridge Crane.

(Brown Hoisting Machinery Company.)

[To face p. 242.

tinuous or multiphase currents are suitable for single motor cranes. For multi-motor cranes the continuous current series wound motor runs fast with a light, and slowly with a heavy, load. But the motor will race if the load is suddenly thrown off, while the three-phase motor under these conditions will show little alteration in speed. It should therefore generally be adopted.

An electric generating plant is now so indispensable in firms, that the old objections to electric cranes no longer hold good; in addition to which, the areas of public supply companies cover the majority of instances, and are still increasing rapidly. Pneumatic cranes require an air compressing plant, but this is not a large affair, and such a plant becomes almost indispensable in most works for other machines besides cranes, such as portable drills, chippers, caulkers, hose-pipes for foundry use, &c.

The question of hoisting machinery is thus seen to be fast becoming a part of the broader question of the power equipment of works, and this has and will continue to have modifying influences in the working out of crane designs.

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